For density g/cm^3	Regulator length mm (in.)	Diameter mm (in.)
1.30–1.40	130 (5 2/16)	100 (4)
1.40–1.50	126 (5)	100 (4)

Weight: approx. 2 kg (4.5 lb) for a standard density regulator with 20 m cable.

Approvals: CE, CSA, SEMKO, NEMKO, DEMKO

LVD approval according to EN61058

CSA approval: Cert no. 1330172

Cl.I Zone 0, Gr. IIC;

CL.I Div.1 Gr A, B, C&D;

Cl.II Gr. E, F&G;

Cl.III when installed to the certified Intrinsically Safe relay, Ex ia, rated for the locations per submitter controll drawing and installation manual.

Intrincically safe circuits are required for the automatic control system. - Use a EX-safety barrier (e.g. Prod. no. 84 01 07).

0080

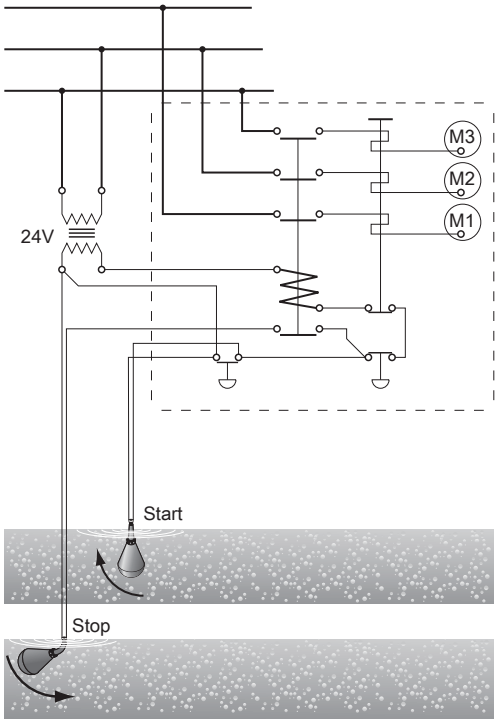
Figure 1

Wiring alternative

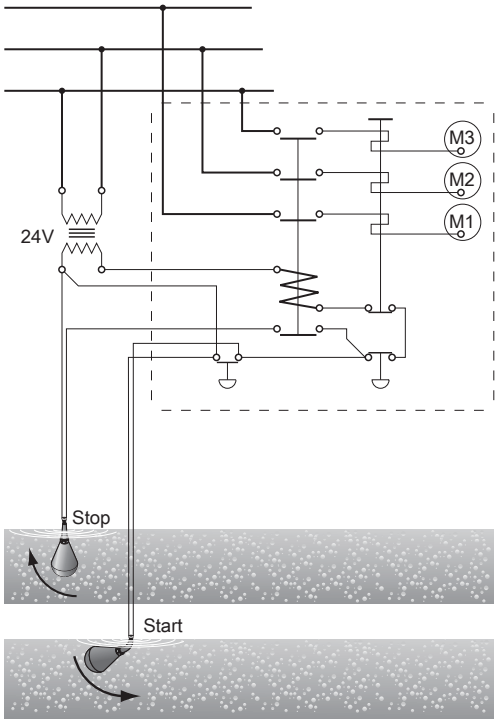
To conform to local regulations, the level regulators are normally connected through a transformer to a low-tension control circuit.

Two regulators are used; one for starting and one for stopping. A third regulator can be connected if an alarm is required at a given level.

Identical regulators can be used for all functions.



Connect the gray and black leads.



Connect the gray and brown leads.

Insulate the brown lead.
Figure 2: Connected for emptying

Insulate the black lead.
Figure 3: Connected for emptying

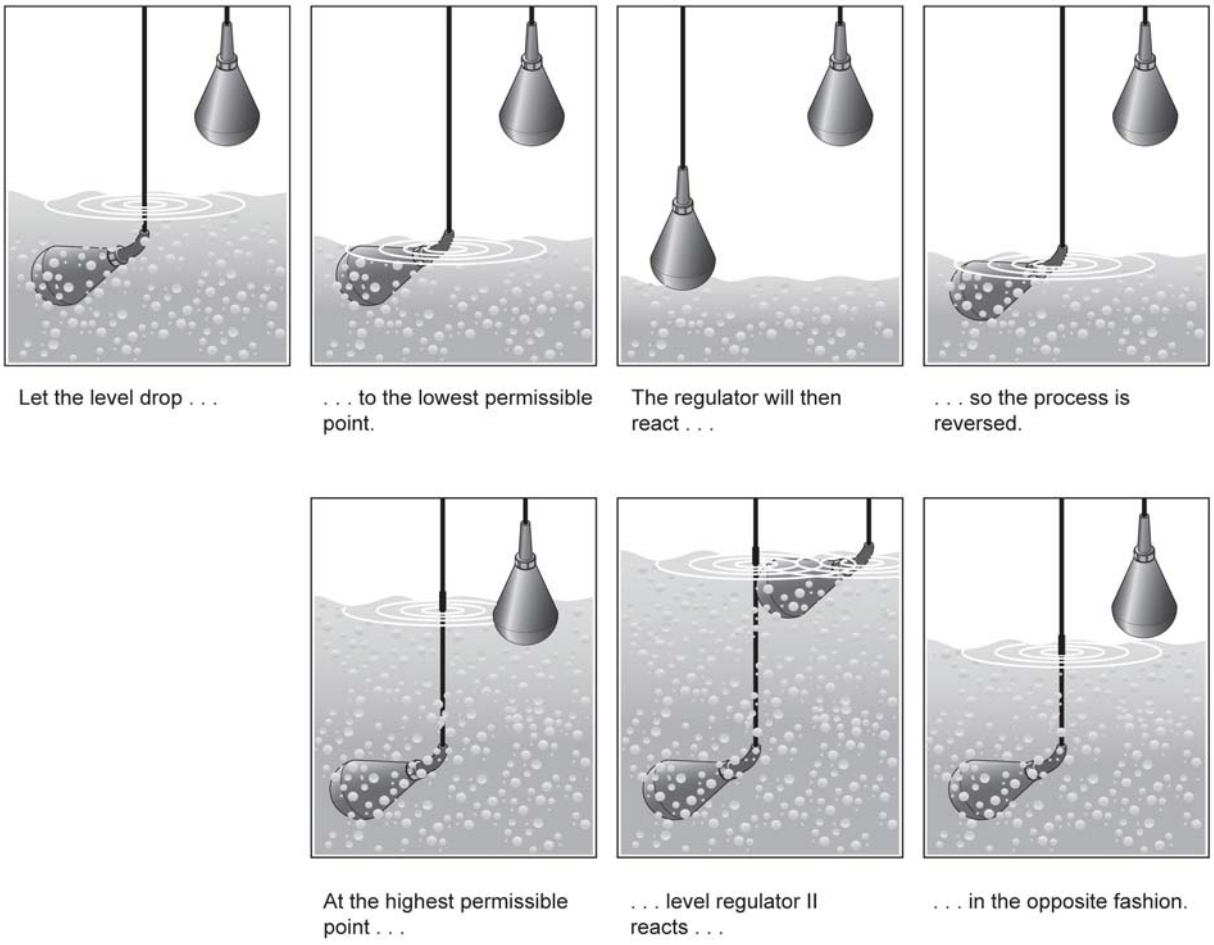


Figure 4

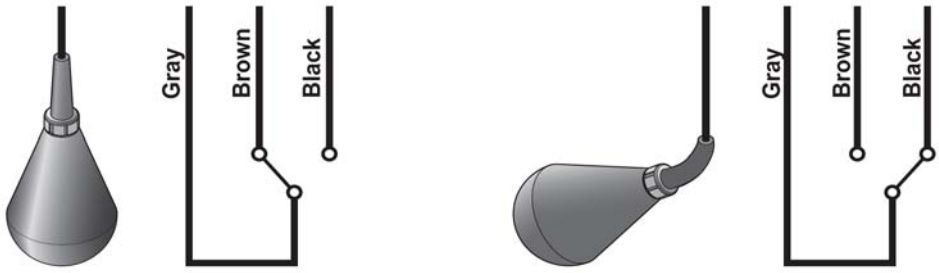


Figure 5: Colour code

Maintenance and repair

ENM-10 is very durable and practically maintenance free. You only have to check on it occasionally, to ensure its continual operation.

- It is recommended to occasionally clean ENM-10, and especially when fat/grease covers the plastic surface.
- At the same time, make an occular inspection of the regulator to make sure neither cable, protective sleeve or plastic casing show any signs of damage.

- A damaged ENM-10 cannot be repaired in any way, due to the hermetic encapsulation. If the unit is found to be damaged, replace it with a new one.
- For Ex-installations, also make absolutely sure that the Ex-barrier (e.g. Prod. no. 84 01 07) is operating correctly - The LED changes when the switch is toggled.

The manufacturers reserve the right to alter performance specification or design without notice.

CHEMICAL RESISTANCE LIST

Chemical resistance list

The liquid in which level regulation is practiced most frequently is, of course, water. Of the millions of regulators in use all over the world today, it is estimated that nine out of ten work in water.

However, with a float body of polypropylene, a cable of PVC or NBR/PVC nitrile/PVC rubber and a bending relief of EPDM rubber, the ENM-10 is virtually insensitive to many aggressive liquids.

The table shows how resistant the ENM-10 equipped with either PVC or NBR/PVC nitrile/PVC rubber cable, is to different chemicals at two different temperatures.

The classification is broken down into the following categories:

0 = No effect, 1 = Minor to moderate and 2 = Severe effect. The sign – means that information is not available.

Keep in mind also that the density of the liquid determines the bouyancy of the regulator. The ENM-10 is made for seven different densities. See *Product description* (page 2).

Always observe local regulations:

Take particular note of:

- risk of fire/explosion
- hygiene requirements

Acids	PVC cable		NBR/PVC nitrile/PVC rubber cable	
	20°C (68°F)	60°C (140°F)	20°C (68°F)	60°C (140°F)
Acetic Acid 50%	1	2	0	0
Acetic Acid 75%	2	2	0	0
Benzoic Acid	2	2	0	0
Boric Acid 5%	0	—	0	0
Butyric Acid	2	2	2	2
Chromic Acid 10%	0	2	2	2
Citric Acid	0	1	0	0
Hydrobromic Acid 5%	1	2	0	0
Hydrochloric Acid 10%	0	1	0	1
Hydrochloric Acid 37%	1	2	0	2
Hydrocyanic Acid 10%	0	0	1	2
Hydrofluoric Acid 5%	0	2	0	1
Hypochloric Acid	1	2	2	2
Maleic Acid	2	2	2	2
Nitric Acid 5%	1	1	1	1
Nitric Acid 65%	2	2	2	2
Oleic Acid	1	2	2	2
Oxalic Acid 50%	1	1	1	2
Phosphoric Acid 25%	0	0	1	2
Phosphoric Acid 85%	0	0	1	2
Sulphuric Acid 10%	1	2	1	2
Sulphuric Acid 78%	2	2	2	2
Tannic Acid	0	0	0	0
Tartaric Acid	1	1	1	1
Bases				
Ammonium Hydroxide	0	—	0	0
Calcium Hydroxide	0	0	0	0
Potassium Hydroxide	1	2	0	0
Sodium Hydroxide	1	2	0	0

Salts	PVC cable		NBR/PVC nitrile/PVC rubber cable	
	20°C (68°F)	60°C (140°F)	20°C (68°F)	60°C (140°F)
Aluminium Chloride	0	0	0	0
Calcium Sulphate	0	0	0	0
Calcium Chloride	0	0	0	0
Calcium Nitrate	0	0	0	0
Copper Chloride	0	0	0	0
Copper Sulphate	0	0	0	0
Ferric Chloride	0	0	0	0
Ferrous Sulphate	0	0	0	0
Magnesium Chloride	0	0	0	0
Potassium Sulphate	0	0	0	0
Potassium Nitrate	0	0	0	0
Potassium Carbonate	1	1	1	1
Potassium Bicarbonate	0	0	0	0
Sodium Sulphate	0	0	0	0
Sodium Chloride	0	0	0	0
Sodium Nitrate	0	0	0	0
Sodium Bicarbonate	0	0	0	0
Sodium Carbonate	0	0	0	0
Tin Chloride	1	1	1	1
Zinc Sulphate	0	0	0	0
Zinc Chloride	0	0	0	0
Oils				
Castor Oil	1	1	1	1
Cocoanut Oil	0	—	0	2
Corn Oil	2	2	2	2
Diesel Oil	2	2	2	2
Linseed Oil	2	2	2	2
Mineral Oils	2	2	2	2
Olive Oil	1	1	1	1
Silicone Oils	0	0	0	0

Solvents and miscellaneous	PVC cable		NBR/PVC nitrile/PVC rubber cable	
	20°C (68°F)	60°C (140°F)	20°C (68°F)	60°C (140°F)
Aceton	2	2	2	2
Aniline	2	2	1	2
Benzene	2	2	2	2
Butyl Alcohol	2	2	0	1
Carbon Tetrachloride	2	2	2	2
Chlorobenzene	2	2	2	2
Chloroform	2	2	2	2
Ethyl Alcohol	2	2	0	1
Ethyl Ether	2	2	2	2
Ethyl Acetate	2	2	2	2
Ethylene Dichloride	2	2	2	2
Ethylene Chloride	2	2	2	2
Formaldehyde 37%	1	2	0	0
Gasoline	2	2	2	2
Kerosene	2	2	2	2
Methyl Alcohol	2	2	0	0
Methyl Ethyl Ketone	2	2	2	2
Methylene Chloride	2	2	2	2
Nitrobenzene	2	2	2	2
Phenol	2	2	2	2
Toluene	2	2	2	2
Trichlorethylene	2	2	2	2
Turpentine	2	2	2	2
Xylene	2	2	2	2
Gases				
Carbon Dioxide	0	0	0	0
Carbon Monoxide	0	0	0	0
Chlorine (wet)	2	2	2	2
Hydrogen Sulphide	0	0	1	1
Sulphur Dioxide (wet)	1	1	2	2

0 = No effect, 1 = Minor to moderate, 2 = Severe effect. – = No information available.

Figure 6

PRODUCT RANGE

Product range

Part no.	For density [g/cm³]	Color of level switch	Type of cable	Cable length [m]	Approvals	For market	Notes
5828800	0,65-0,80	Blue	1	20	CE		
5828801	0,80-0,95	Blue	1	20	CE		
5828802	0,95-1,10	Blue	1	6	CE		
5828803	0,95-1,10	Blue	1	13	CE		
5828804	0,95-1,10	Blue	1	20	CE		
5828805	1,05-1,20	Blue	1	20	CE		
5828806	1,2-1,3	Blue	1	20	CE		
5828807	1,3-1,4	Blue	1	20	CE		
5828808	1,4-1,5	Blue	1	20	CE		
5828809	0,65-0,80	Grey	5	20	CSA/CE	Canada	
5828810	0,80-0,95	Grey	5	20	CSA/CE	Canada	
5828811	0,95-1,10	Grey	5	6	CSA/CE	Canada	
5828812	0,95-1,10	Grey	5	13	CSA/CE	Canada	
5828813	0,95-1,10	Grey	5	20	CSA/CE	Canada	
5828814	1,05-1,20	Grey	5	20	CSA/CE	Canada	
5828815	1,2-1,3	Grey	5	20	CSA/CE	Canada	
5828816	1,3-1,4	Grey	5	20	CSA/CE	Canada	
5828817	1,4-1,5	Grey	5	20	CSA/CE	Canada	
5828818	0,65-0,80	Grey	1	20	CSA/CE	Canada	
5828819	0,80-0,95	Grey	1	20	CSA/CE	Canada	
5828820	0,95-1,10	Grey	1	6	CSA/CE	Canada	
5828821	0,95-1,10	Grey	1	13	CSA/CE	Canada	
5828822	0,95-1,10	Grey	1	20	CSA/CE	Canada	
5828823	1,05-1,20	Grey	1	20	CSA/CE	Canada	
5828824	1,2-1,3	Grey	1	20	CSA/CE	Canada	
5828825	1,3-1,4	Grey	1	20	CSA/CE	Canada	
5828826	1,4-1,5	Grey	1	20	CSA/CE	Canada	
5828827	0,65-0,80	Blue	2	20	CE	USA	
5828828	0,80-0,95	Blue	2	20	CE	USA	
5828829	0,95-1,10	Blue	2	6	CE	USA	
5828830	0,95-1,10	Blue	2	13	CE	USA	
5828831	0,95-1,10	Blue	2	20	CE	USA	
5828832	1,05-1,20	Blue	2	20	CE	USA	
5828833	1,2-1,3	Blue	2	20	CE	USA	
5828834	1,3-1,4	Blue	2	20	CE	USA	
5828835	1,4-1,5	Blue	2	20	CE	USA	
5828836	0,95-1,10	Grey	5	30	CSA/CE	Canada	
5828837	0,95-1,10	Grey	5	50	CSA/CE	Canada	
5828838	0,95-1,10	Grey	5	100	CSA/CE	Canada	
5828839	0,95-1,10	Grey	5	150	CSA/CE	Canada	
5828851	0,95-1,10	Red	3	65	CE		
5828852	0,95-1,10	Red	3	6	CE		
5828853	0,95-1,10	Red	3	13	CE		
5828854	0,95-1,10	Red	3	20	CE		
5828855	0,95-1,10	Red	3	6	CSA/CE	Canada	
5828856	0,95-1,10	Red	3	13	CSA/CE	Canada	
5828857	0,95-1,10	Red	3	20	CSA/CE	Canada	

Cont. →

Figure 7

5828858	0,95-1,10	Red	4	6	CE	USA	
5828859	0,95-1,10	Red	4	13	CE	USA	
5828860	0,95-1,10	Red	4	20	CE	USA	
5828870	0,65-0,80	Blue	5	20	CE		
5828871	0,80-0,95	Blue	5	20	CE		
5828872	0,95-1,10	Blue	5	6	CE		
5828873	0,95-1,10	Blue	5	13	CE		
5828874	0,95-1,10	Blue	5	20	CE		
5828875	1,05-1,20	Blue	5	20	CE		
5828876	1,2-1,3	Blue	5	20	CE		
5828877	1,3-1,4	Blue	5	20	CE		
5828878	1,4-1,5	Blue	5	20	CE		
5828879	0,95-1,10	Blue	1	65	CE		
5828880	0,95-1,10	Blue	1	30	CE		
5828881	0,95-1,10	Blue	1	50	CE		
5828882	0,95-1,10	Grey	1	30	CSA/CE	Canada	
5828883	0,95-1,10	Grey	1	50	CSA/CE	Canada	
5828884	0,95-1,10	Blue	2	30	CE	USA	
5828885	0,95-1,10	Blue	2	50	CE	USA	
5828886	0,95-1,10	Red	3	30	CE		
5828887	0,95-1,10	Red	3	50	CE		
5828890	0,95-1,10	Blue	5	30	CE		
5828891	0,95-1,10	Blue	5	50	CE		
5828892	0,95-1,10	Red	3	6	CE	Japan	
5828893	0,95-1,10	Red	3	13	CE	Japan	
5828894	0,95-1,10	Red	3	20	CE	Japan	
5828895	0,95-1,10	Blue	1	6	CE	Japan	
5828896	0,95-1,10	Blue	1	13	CE	Japan	
5828897	0,95-1,10	Blue	1	20	CE	Japan	
5828898	0,95-1,10	Blue	1	50	CE	Japan	
5947919	0,95-1,10	Blue	5	20	CE		Designed for low current and slow movements
5947920	0,95-1,10	Grey	5	20	CSA/CE		Designed for low current and slow movements

Type of cable:

1. Blue PVC jacket with color coding of wires: Grey/Brown/Black
2. Blue PVC jacket with color coding of wires: Red/White/Black
3. Red PVC jacket with color coding of wires: Grey/Brown/Black
4. Red PVC jacket with color coding of wires: Red/White/Black
5. BLACK NBR/PVC jacket with color coding of wires: Grey/Brown/Black (NBR=Nitrile rubber)

Xylem |ˈzīləm|

1) The tissue in plants that brings water upward from the roots
2) A leading global water technology company

We're 12,000 people unified in a common purpose: creating innovative solutions to meet our world's water needs. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. We move, treat, analyze, and return water to the environment, and we help people use water efficiently, in their homes, buildings, factories and farms. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise, backed by a legacy of innovation.

For more information on how Xylem can help you, go to xyleminc.com

xylem
Let's Solve Water

Xylem Water Solutions AB
Gesällvägen 33
174 87 Sundbyberg
Sweden
Tel. +46-8-475 60 00
Fax +46-8-475 69 00
http://tpi.xyleminc.com

Visit our Web site for the latest version of this document and more information

The original instruction is in English. All non-English instructions are translations of the original instruction.

891480_11.1_en.GB_2012-01_TS_ENM-10

This page is intentionally left blank

CS-451-500 : Identification sheet

VWTC PROJECT NUMBER:	5000218009	REV:	1
PROJECT NAME:	AEM AMARUQ	SUBMITTED TO (COMPANY):	AGNICO EAGLE MINES
ENGINEER:	Gabriel Hébert	SUBMITTED TO (RESPONSIBLE)	
PROJECT MANAGER:	Clément B	PROJECT NUM REFERENCE.:	
PHONE NUMBER:		LOT NUMBER:	

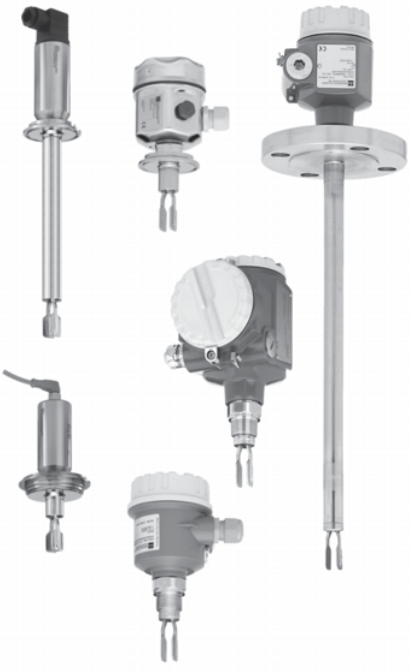
SUPPLIER	EQPT CODE	EQPT TAG NO	DIA	DESCRIPTION	INFO 1	INFO 2	INFO 3	APPLIC.	NOTE	REV
E&H	ST-451-507	LSLL4-012		LOW LOW LEVEL SWITCH	LEVEL SWITCH // Manuf : E&H // model : FTL51-UGN2CBAE5A Point level/density, vibronic. Extension tube. Approval: U CSA C/US General Purpose Process Conn.: GN2 Thread ANSI NPT1, 316L	Probe Length; Type: CB 6 Inch; 316L, Ra<3.2um/126uin Electronics; Output: A FEL50A; PROFIBUS PA Housing; Cable Entry: E5 F13 NEMA Type 4X/6P Encl. / F17		SLUDGE TANK		rev1

This page is intentionally left blank

Technical Information

Liquiphant M
FTL50, FTL51, FTL50H, FTL51H

Vibronic



Point level switch for all kinds of liquids

Application

- Process temperatures from −50 °C to 150 °C (-58 to 302 °F)
- Pressures up to 100 bar (1450 psi)
- Viscosities up to 10,000 mm^2/s (cSt)
- For liquids with densities ≥ 0.5 g/cm^3 (SGU)

FTL50: Compact design
FTL51: Extension pipe up to 3 m (9.8 ft) and up to 6 m (20 ft) on request
FTL50H, FTL51H: Certified for the food and pharmaceutical industries

Ideal substitute for float switches, as reliable function not affected by flow, turbulence, bubbles, foam, vibration, solids content or buildup.

Your benefits

- Recommended for safety systems requiring functional safety to SIL2/SIL3 as per IEC 61508/IEC 61511-1
- Design in accordance with ASME B31.3
- Recommended for use in sterile applications in the life science industry (design in accordance with ASME BPE)
- No adjustment: quick, low-cost startup
- No mechanically moving parts: no maintenance, no wear, long operating life
- Functional safety: Monitoring of tuning fork for damage
- Compact stainless steel housing (optional): the IP69K protection rating guarantees that the unit remains impermeable, even in the event of intensive cleaning or flooding for several hours.

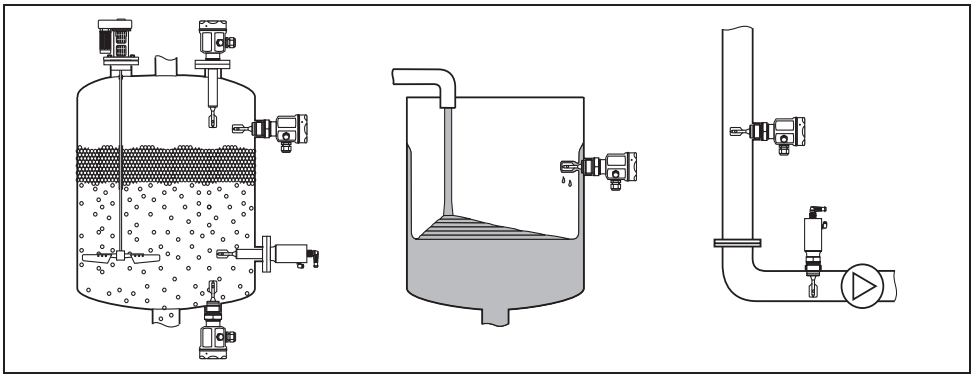
Endress+Hauser
People for Process Automation

Table of contents

Application

Point level detection

Maximum or minimum detection in tanks or pipes containing all kinds of liquids, including use in hazardous areas, food and pharmaceuticals.



L00-FTL5xxxx-11-05-xx-xx-000

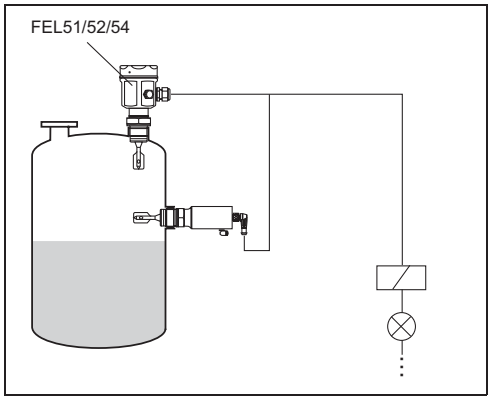
Function and system design

Measuring principle

The sensor's fork vibrates at its intrinsic frequency. This frequency is reduced when covered with liquid. This change in frequency causes the point level switch to switch.

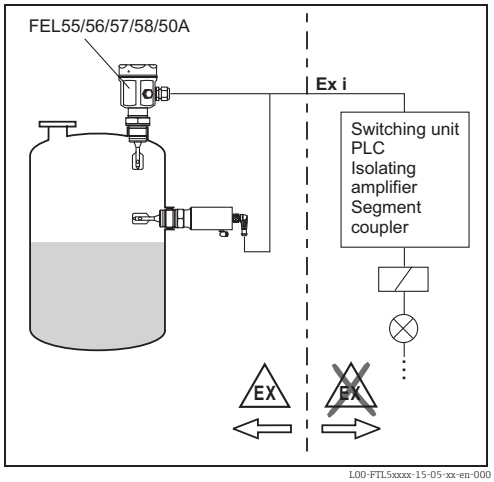
Modularity

Point level switch
Liquiphant M FTL with electronic versions
FEL51, FEL52, FEL54



L00-FTL5xxxx-15-05-xx-xx-000

Point level switch
Liquiphant M FTL with electronic versions
FEL55, FEL56, FEL57, FEL58
for connecting to a separate switching unit
or an isolating amplifier FEL50A
for connecting to a PROFIBUS PA segment



L00-FTL5xxxx-15-05-xx-en-000

Electronic versions	FEL51: Two-wire AC version; Switches the load directly into the power supply circuit via an electronic switch. FEL52: Three-wire DC version; Switches the load via the transistor (PNP) and separate connection e.g. in conjunction with programmable logic controllers (PLCs), DI modules as per EN 61131-2. FEL54: Universal current version with relay output; Switches the loads via 2 floating change-over contacts. FEL55: Signal transmission 16/8 mA on two-wire cabling e.g. in conjunction with programmable logic controllers (PLCs), AI modules 4 to 20 mA as per EN 61131-2. FEL56: For separate switching unit; signal transmission L-H edge 0.6 to 1.0 / 2.2 to 2.8 mA to EN 50227 (NAMUR) on two-wire cabling. FEL58: For separate switching unit; signal transmission H-L edge 2.2 to 3.5 / 0.6 to 1.0 mA to EN 50227 (NAMUR) on two-wire cabling. Checking of connecting cabling and other devices by pressing a key on the electronic insert. FEL57: For separate switching unit; PFM signal transmission; Current pulses superposed on the power supply along the two-wire cabling. Proof test from the switching unit without changing levels. FEL50A: For connecting to PROFIBUS PA; Cyclic and acyclic data exchange acc. to PROFIBUS-PA Profile 3.0 Discrete Input
Electronics for continuous density measurement	FEL50D: For connecting to Density Computer FML621
Galvanic isolation	FEL51, FEL52, FEL50A: between sensor and power supply FEL54: between sensor and power supply and load FEL55, FEL56, FEL57, FEL58, FEL50D: see connected switching unit
Design	FTL50: Compact FTL51: With extension pipe FTL50H: Compact, with polished tuning fork and hygienic process connections FTL51H: With extension pipe, polished tuning fork and hygienic process connections

Input

Measured variable	Level (limit value)
Measuring range (detection range)	FTL50: dependent on mounting point FTL51: dependent on mounting point and the extension pipe ordered. Standard extension pipe up to 3 m (9.8 ft) and up to 6 m (20 ft) on request.
Density	Setting on the electronic insert > 0.5 g/cm³ (SGU) or > 0.7 g/cm³ (SGU) (others on request)

Electronic insert FEL51 (AC 2-wire)

Power supply

Supply voltage: AC 19 to 253 V
Power consumption: < 0.83 W
Residual current consumption: < 3.8 mA
Short-circuit protection
Overvoltage protection FEL51: overvoltage category III

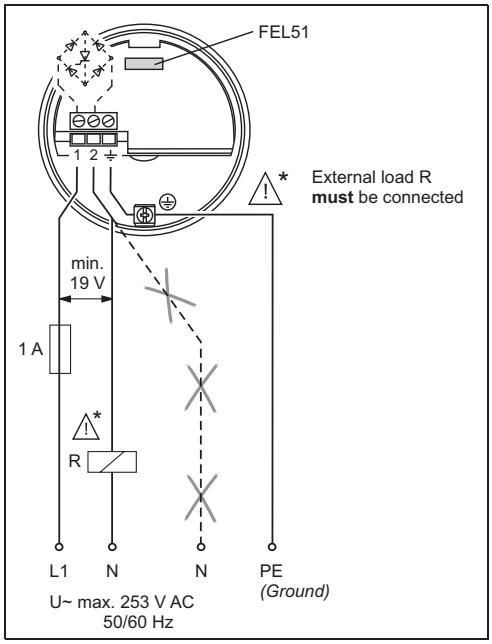
Electrical connection

Two-wire AC connection

Switches the load directly into the power supply circuit via an electronic switch.

Always connect in series with a load!

Check the following:
- The residual current in blocked state (up to 3.8 mA)
- That for low voltage
  - the voltage drop across the load is such that the minimum terminal voltage at the electronic insert (19 V) when blocked is not undershot.
  - the voltage drop across the electronics when switched through is observed (up to 12 V)
- That a relay cannot de-energize with holding power below 3.8 mA.
  If this is the case, a resistor should be connected parallel to the relay. An RC module is available under the part number: 71107226
- When selecting the relay, pay attention to the holding power / rated power (see "Connectable load")



L00-FTL5xxxx-04-05-xx-en-007

Output signal

I_L = load current (switched through)

< 3.8 mA = residual current (blocked)

☼ = lit

● = unlit

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.		1 —I_L→ 2	☼	●
		1 - - < 3.8 mA - - → 2	☼	☼
Min.		1 —I_L→ 2	☼	●
		1 - - < 3.8 mA - - → 2	☼	☼

L00-FTL2xxxx-07-05-xx-xx-000

L00-FTL5xxxx-04-05-xx-xx-001

Signal on alarm

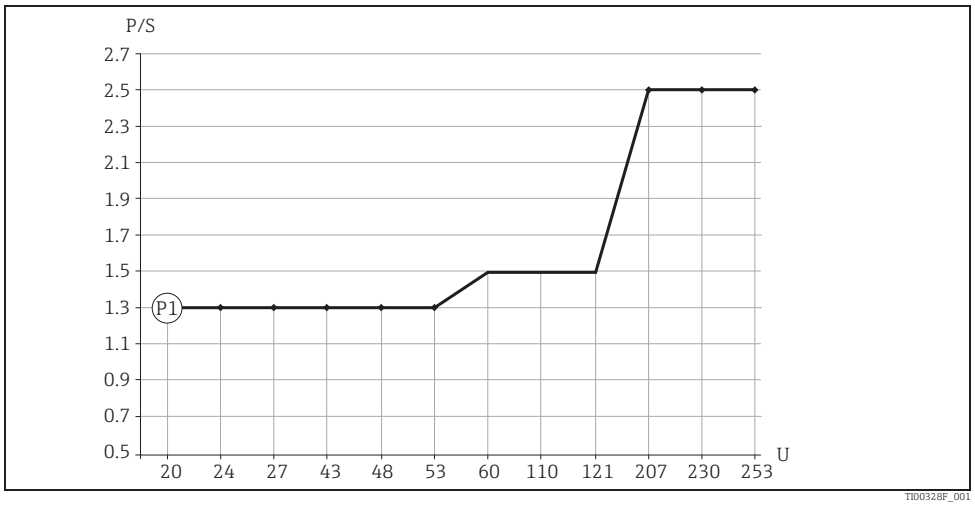
Output signal on power failure or in the event of damaged sensor: < 3.8 mA

Connectable load

- Voltage drop via FEL51 ≤ 12 V
- Residual current if electrical switch is blocked: ≤ 3.8 mA
- Load switched directly into the power supply circuit via the thyristor.
  Transient (40 ms) ≤ 1.5 A, ≤ 375 VA at 253 V or ≤ 36 VA at 24 V (not short-circuit-proof)

The load is switched via an electronic switch directly in the power circuit.
Always connect in series with a load!
Not suitable for connection to low-voltage PLC inputs!

Selection guide for relays



Minimum nominal power of load
P/S nominal power in [W] / [VA]
U operating voltage in [V]

Position	Operating voltage	Nominal power	
		min.	max.
P1 AC operation	24 V 110 V 230 V	> 1.3 VA > 1.5 VA > 2.5 VA	< 6 VA < 27.5 VA < 57.5 VA

Relays with less nominal power can be operated via an RC module connected in parallel (optional).

Electronics FEL51 (AC, in compact housing)

Power supply

Supply voltage: AC 19 to 253 V
Power consumption: < 0.83 W
Residual current consumption: < 3.8 mA
Short-circuit protection
Overvoltage protection FEL51: overvoltage category III

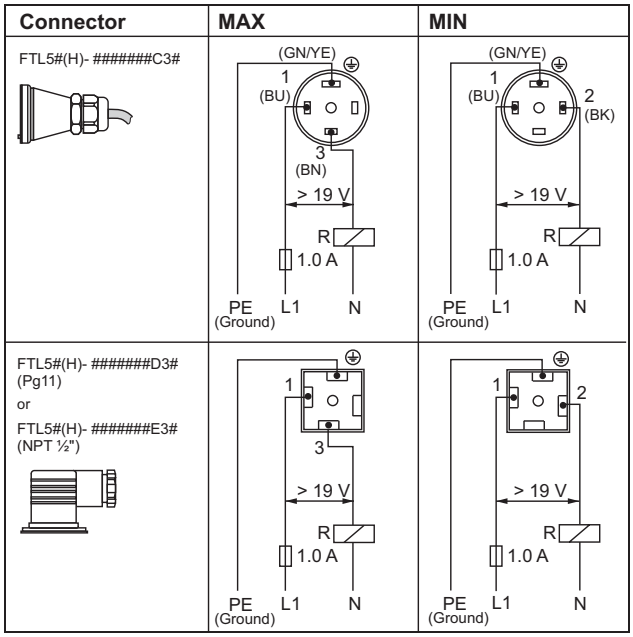
Electrical connection

Two-wire AC connection

Switches the load directly into the power supply circuit via an electronic switch.

Always connect in series with a load!

Check the following:
- The residual current in blocked state (up to 3.8 mA)
- That for low voltage
  - the voltage drop across the load is such that the minimum terminal voltage at the electronic insert (19 V) when blocked is not undershot.
  - the voltage drop across the electronics when switched through is observed (up to 12 V)



L00-FTL5xxxx-04-05-xx-en-008

- That a relay cannot de-energize with holding power below 3.8 mA.
  If this is the case, a resistor should be connected parallel to the relay (e.g. RC module: part number 71107226).

Output signal

I_L = load current (switched through)

< 3.8 mA = residual current (blocked)

☼ = lit

● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.		1 —I_L→ 3	☼	●
		1 --< 3.8 mA--→ 3	☼	☼
Min.		1 —I_L→ 2	☼	●
		1 --< 3.8 mA--→ 2	☼	☼

L00-FTL5xxxx-04-05-xx-xx-001a

Signal on alarm

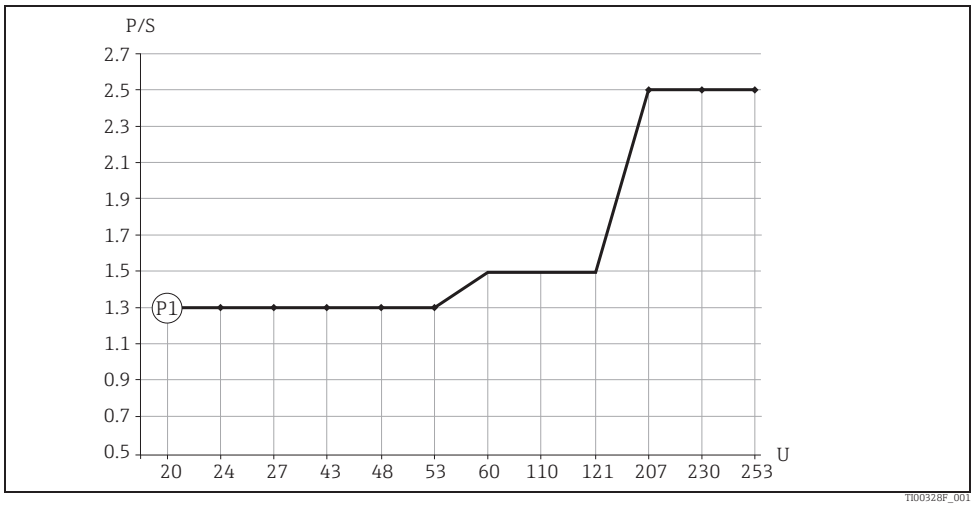
Output signal on power failure or in the event of damaged sensor: < 3.8 mA

Connectable load

- Voltage drop via FEL51 ≤ 12 V
- Residual current if electrical switch is blocked: ≤ 3.8 mA
- Load switched directly into the power supply circuit via the thyristor.
  Transient (40 ms) ≤ 1.5 A, ≤ 375 VA at 253 V or ≤ 36 VA at 24 V (not short-circuit-proof)

The load is switched via an electronic switch directly in the power circuit.
Always connect in series with a load!
Not suitable for connection to low-voltage PLC inputs!

Selection guide for relays



Minimum nominal power of load
P/S nominal power in [W] / [VA]
U operating voltage in [V]

Position	Operating voltage	Nominal power	
		min.	max.
P1	24 V	> 1.3 VA	< 6 VA
AC operation	110 V	> 1.5 VA	< 27.5 VA
	230 V	> 2.5 VA	< 57.5 VA

Relays with less nominal power can be operated via an RC module connected in parallel (optional).

Electronic insert FEL52 (DC PNP)

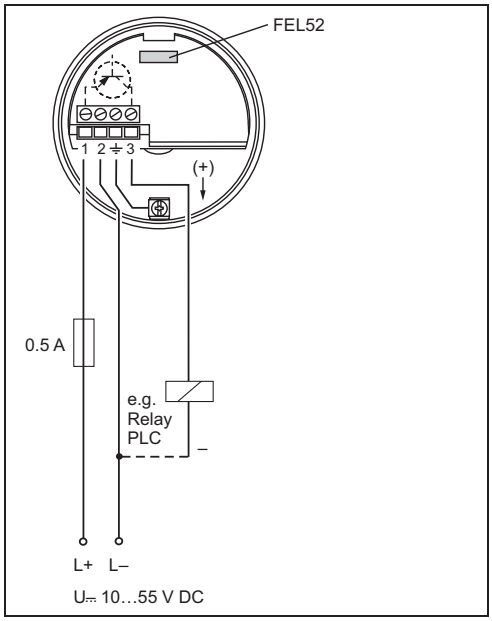
Power supply

Supply voltage: DC 10 to 55 V
Ripple: ≤ 1.7 V, 0 to 400 Hz
Current consumption: ≤ 15 mA
Power consumption: ≤ 0.83 W
Reverse polarity protection
Overvoltage protection FEL52: overvoltage category III

Electrical connection

Three-wire DC connection

Switches the load via the transistor (PNP) and separate connection.
Preferably used with programmable logic controllers (PLC),
DI modules as per EN 61131-2.
Positive signal at switching output of the electronics (PNP); Output blocked on reaching point level.



L00-FTL5xxxx-04-05-xx-en-001

Output signal

I_L = load current (switched through)

< 100 µA = residual current (blocked)

☼ = lit

● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.		L+ 1 → I_L → + 3	☼	●
		1 --- < 100 µA ---→ 3	☼	☼
Min.		L+ 1 → I_L → + 3	☼	●
		1 --- < 100 µA ---→ 3	☼	☼

L00-FTL5xxxx-04-05-xx-xx-004

Signal on alarm

Output signal on power failure or in the event of damaged sensor: < 100 µA

Connectable load

- Load switched via the transistor and separate PNP connection, ≤ DC 55 V
- Load current ≤ 350 mA (pulsed overload and short-circuit protection)
- Residual current < 100 µA (with transistor blocked).
- Capacitance load ≤ 0.5 µF at 55 V, ≤ 1.0 µF at 24 V
- Residual voltage < 3 V (with transistor switched through);

Electronics FEL52 (DC PNP, in compact housing)

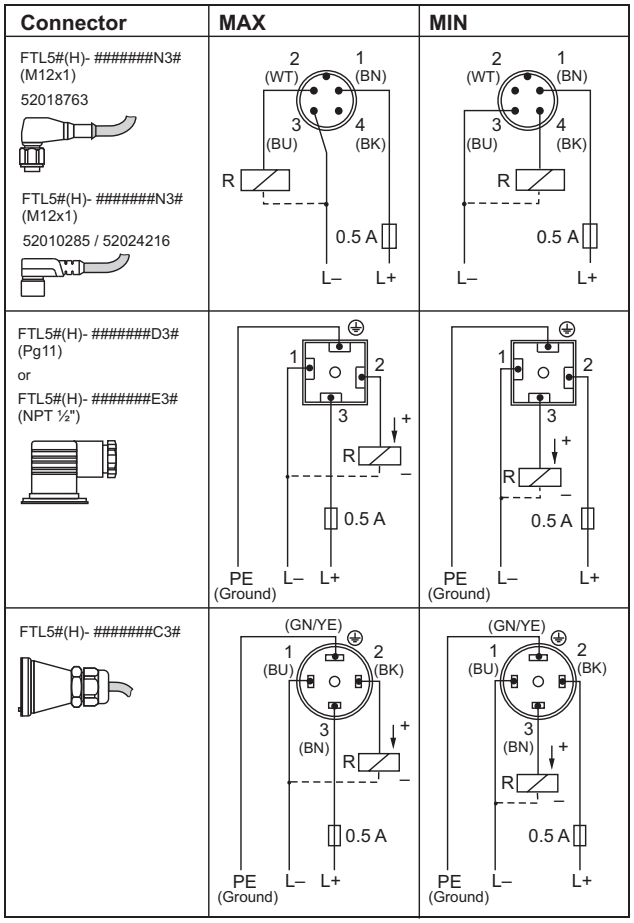
Power supply

Supply voltage: DC 10 to 55 V
Ripple: ≤ 1.7 V, 0 to 400 Hz
Current consumption: ≤ 15 mA
Power consumption: ≤ 0.83 W
Reverse polarity protection
Overvoltage protection FEL52: overvoltage category III

Electrical connection

Three-wire DC connection

Preferably used with programmable logic controllers (PLC), DI module as per EN 61131-2. Positive signal at switching output of the electronics (PNP); Output blocked on reaching point level.



L00-FTL5xxxx-04-05-xx-en-010

Output signal

With valve connector or cable tail

I_L = load current (switched through)

< 100 µA = residual current (blocked)

☼ = lit

● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.		L+ 3 → I_L → + 2	☼	●
		L+ 3 - - < 100 µA - - → + 2	☼	☼
Min.		L+ 2 → I_L → + 3	☼	●
		L+ 2 - - < 100 µA - - → + 3	☼	☼

L00-FTL5xxxx-04-05-xx-xx-004a

With M12x1 connector 52010285 / 52024216 (without LEDs)

L00-FTL5xxxx-16-05-xx-xx-002

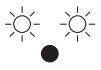
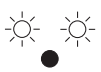
I_L = load current (switched through)

< 100 µA = residual current (blocked)

☼ = lit

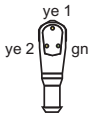
● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Safety mode	Level	Output signal	LEDs
Max.		L+ 1 → I_L → – 2	
		L+ 1 → < 100 µA → – 2	
Min.		L+ 1 → I_L → – 4	
		L+ 1 → < 100 µA → – 4	

L00-FTL5xxxx-04-05-xx-xx-010

With M12x1 connector 52018763 (with LEDs)



L00-FTL5xxxx-16-05-xx-xx-001

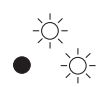
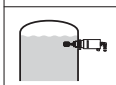
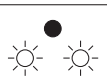
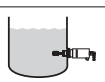
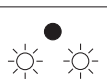
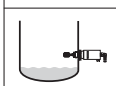
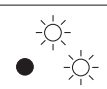
I_L = load current (switched through)

< 100 µA = residual current (blocked)

☼ = lit

● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Safety mode	Level	Output signal	LEDs
Max.		L+ 1 → I_L → – 2	
		L+ 1 → < 100 µA → – 2	
Min.		L+ 1 → I_L → – 4	
		L+ 1 → < 100 µA → – 4	

L00-FTL5xxxx-04-05-xx-xx-011

Signal on alarm

Output signal on power failure or in the event of damaged sensor: < 100 µA

Connectable load

- Load switched via the transistor and separate PNP connection, ≤ DC 55 V
- Load current ≤ 350 mA (pulsed overload and short-circuit protection)
- Residual current < 100 µA (with transistor blocked).
- Capacitance load ≤ 0.5 µF at 55 V, ≤ 1.0 µF at 24 V
- Residual voltage < 3 V (with transistor switched through);

Electronic insert FEL54 (AC/DC with relay output)

Power supply

Supply voltage: AC 19 to 253 V, 50/60 Hz or DC 19 to 55 V
Power consumption: ≤ 1.3 W
Reverse polarity protection
Overvoltage protection FEL54: overvoltage category III

Electrical connection

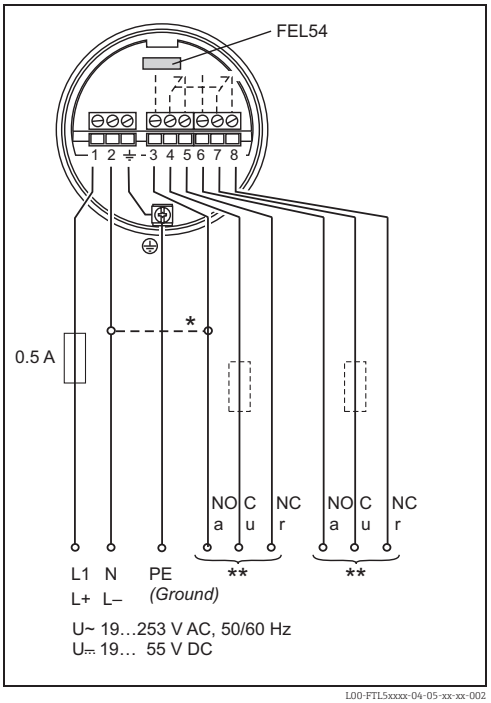
Universal current connection with relay output

Power supply:
Please note the different voltage ranges for AC and DC.

Output:
When connecting an instrument with high inductance, provide a spark arrester to protect the relay contact.
A fine-wire fuse (depending on the load connected) protects the relay contact on short-circuiting.
Both relay contacts switch simultaneously.

* When jumpered, the relay output works with NPN logic.

** See "Connectable load"

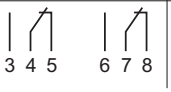


L00-FTL5xxxx-04-05-xx-xx-002

Output signal

= relay energized
= relay de-energized
= lit
= unlit

L00-FTL2xxxx-07-05-xx-xx-001

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.			☼	●
			☼	☼
Min.			☼	●
			☼	☼

L00-FTL5xxxx-04-05-xx-xx-005

Signal on alarm

Output signal on power failure or in the event of damaged sensor: relay de-energized

Connectable load

- Loads switched via 2 floating change-over contacts (DPDT).
- I~ ≤ 6 A (Ex de 4 A), U~ ≤ AC 253 V; P~ ≤ 1500 VA, cos φ = 1, P~ ≤ 750 VA, cos φ > 0.7
- I⎓ ≤ 6 A (Ex de 4 A) to DC 30 V , I⎓ ≤ 0.2 A to 125 V
- When connecting a low-voltage circuit with double insulation according to IEC 1010, the following applies: the sum of the voltages of the relay output and power supply is ≤ 300 V
- The electronic insert FEL52 DC-PNP is preferred for low DC load currents (e.g. when connecting to a PLC)
- Relay contact material: silver/nickel AgNi 90/10

Electronic insert FEL55 (8/16 mA)

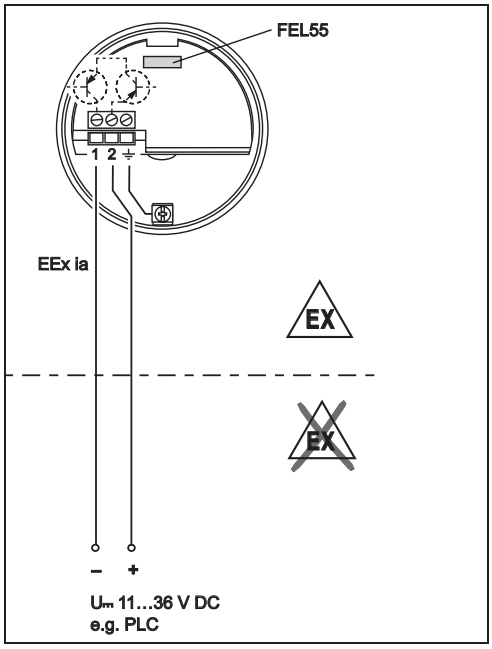
Power supply

Supply voltage: DC 11 to 36 V
Power consumption: < 600 mW
Reverse polarity protection
Overvoltage protection FEL55: overvoltage category III

Electrical connection

Two-wire connection for separate switching unit

For separate switching unit.
Signal transmission 16/8 mA on two-wire cabling.
For connection to programmable logic controllers (PLCs) for example,
AI module 4 to 20 mA to EN 61131-2.
Output signal jump from high to low current on point level.



L00-FTL5xxxx-04-05-xx-en-000

Output signal

~ 16 mA = 16 mA ± 5 %

~ 8 mA = 8 mA ± 6 %

☼ = lit

● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.		+ 2 ~16 mA 1	☼	●
		+ 2 ~8 mA 1	☼	☼
Min.		+ 2 ~16 mA 1	☼	●
		+ 2 ~8 mA 1	☼	☼

L00-FTL5xxxx-04-05-xx-xx-006

Signal on alarm

Output signal on power failure or in the event of damaged sensor: < 3.6 mA

Connectable load

- R = (U - 11 V) : 16.8 mA
- U = connection voltage: DC 11 to 36 V

Example: PLC with 250 Ω with 2-wire version

250 Ω = (U – 11V) / 16.8 mA
4.2 [Ω /A] = U – 11 V
U = 15.2 V

Electronic insert FEL56 (NAMUR L-H edge)

Power supply

Power consumption: < 6 mW at I < 1 mA; < 38 mW at I = 2.8 mA
Connection data interface: IEC 60947-5-6

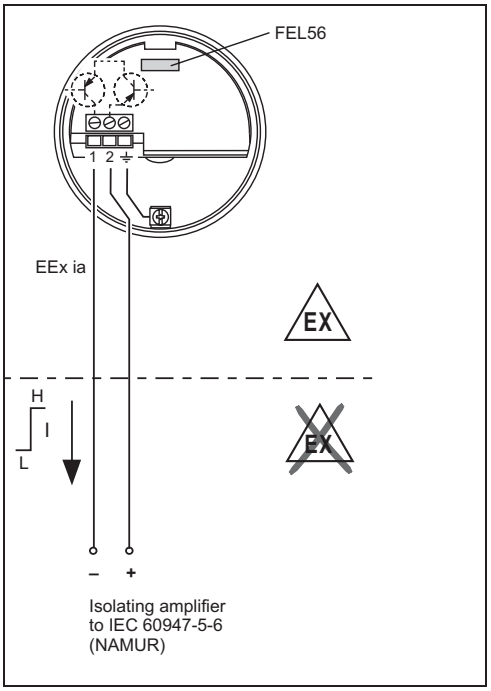
Electrical connection

Two-wire connection for separate switching unit

For connecting to isolating amplifiers acc. to NAMUR (IEC 60947-5-6), e.g. FTL325N, FTL375N from Endress+Hauser.
Output signal jump from low to high current on point level.

(L–H edge)

Connecting to multiplexer:
Set clock time to min. 2 s.



L00-FTL5xxxx-04-05-xx-en-004

Output signal

= lit
= flashes
= unlit

L00-FTL5xxxx-07-05-xx-xx-002

Safety mode	Level	Output signal	LEDs green	LEDs red
Max.		0.6 … 1.0 mA	☼	●
		2.2 … 2.8 mA	☼	☼
Min.		0.6 … 1.0 mA	☼	●
		2.2 … 2.8 mA	☼	☼

L00-FTL5xxxx-04-05-xx-xx-003

Signal on alarm

Output signal in the event of damaged sensor: > 2.2 mA

Connectable load

- See Technical Data of the isolating amplifier connected according to IEC 60947–5–6 (NAMUR)

Electronic insert FEL58 (NAMUR H-L edge)

Power supply

Power consumption: < 6 mW at I < 1 mA; < 38 mW at I = 3.5 mA
Connection data interface: IEC 60947-5-6

Electrical connection

Two-wire connection for separate switching unit

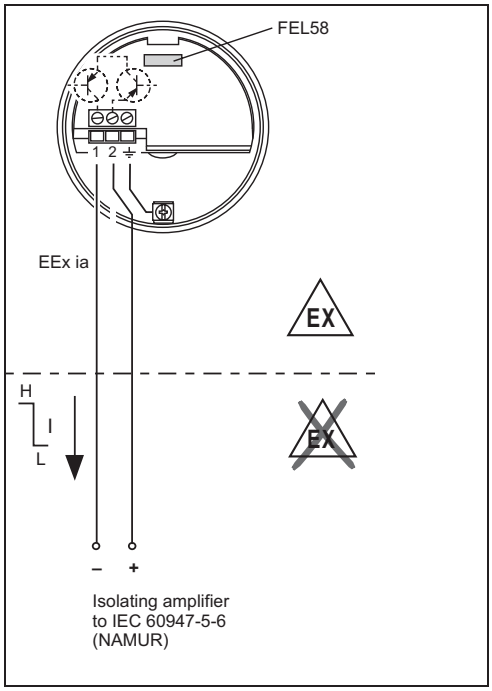
For connecting to isolating amplifiers as per NAMUR (IEC 60947-5-6), e.g. FTL325N, FTL375N from Endress+Hauser.
Output signal jump from high to low current on point level.

(H–L edge)

Additional function:
Test key on the electronic insert.
Pressing the key breaks the connection to the isolating amplifier.

Note!
In Ex–d applications, the additional function can only be used if the housing is not exposed to an explosive atmosphere.

Connecting to multiplexer:
Set clock time to min. 2 s.



L00-FTL5xxxx-04-05-xx-en-002

Output signal

☼ = lit
☼ = flashes
● = unlit

L00-FTL5xxxx-07-05-xx-xx-002

Safety mode	Level	Output signal	LEDs green	LEDs yellow
Max.		+ 2 → 1 2.2 … 3.5 mA	☼	☼
		+ 2 → 1 0.6 … 1.0 mA	☼	●
Min.		+ 2 → 1 2.2 … 3.5 mA	☼	☼
		+ 2 → 1 0.6 … 1.0 mA	☼	●

L00-FTL5xxxx-04-05-xx-xx-007

Signal on alarm

Output signal in the event of damaged sensor: < 1.0 mA

Connectable load

- See Technical Data of the isolating amplifier connected according to IEC 60947–5–6 (NAMUR)
- Connection also to isolating amplifiers which have special safety circuits (I > 3.0 mA)

Electronics FEL58 (NAMUR H-L edge, in compact housing)

Power supply

Power consumption: < 6 mW at I < 1 mA; < 38 mW at I = 3.5 mA
Connection data interface: IEC 60947-5-6

Electrical connection

Two-wire connection for separate switching unit

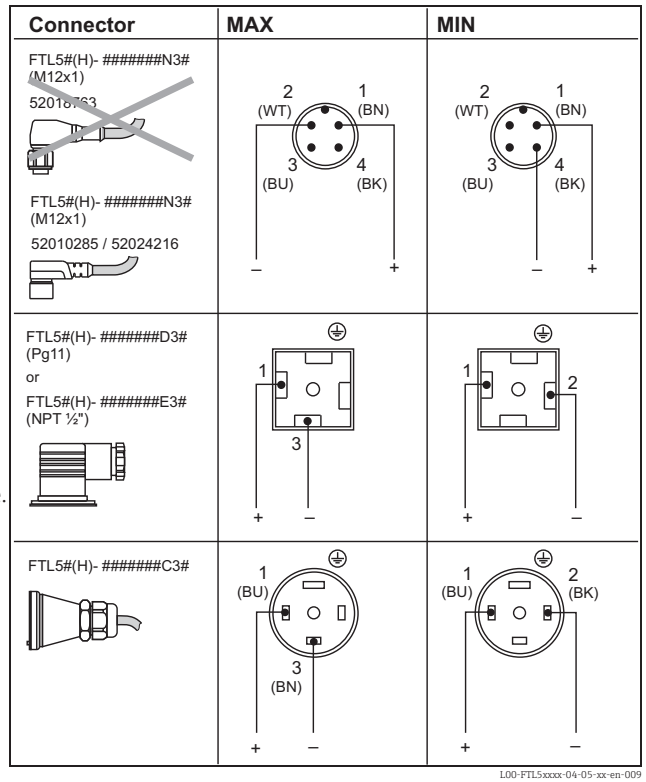
For connecting to isolating amplifiers acc. to NAMUR (IEC 60947-5-6), e.g. FTL325N, FTL375N from Endress+Hauser. Output signal jump from high to low current on point level.

(H–L edge)

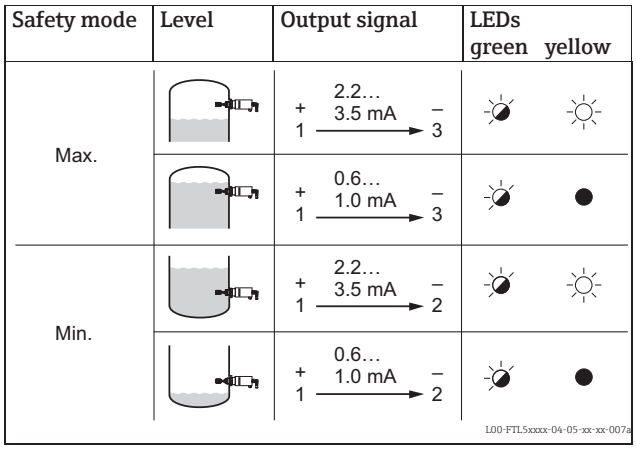
Additional function:
If the test magnet is held against the marking on the nameplate, the output signal is inverted.

Connecting to multiplexer:
Set clock time to min. 3 s.

The NAMUR interface has a defined power consumption rate. Thus, it is not possible to use the M12 connector with an integrated LED (52018763).



Output signal



= lit

= flashes

= unlit

L00-FTL5xxxx-07-05-xx-xx-002

Signal on alarm

Output signal in the event of damaged sensor: < 1.0 mA

Connectable load

- See Technical Data of the isolating amplifier connected according to IEC 60947–5–6 (NAMUR)
- Connection also to isolating amplifiers which have special safety circuits (I > 3.0 mA)

Electronic insert FEL57 (PFM)

Power supply

Supply voltage: DC 9.5 to 12.5 V
Current consumption: 10 to 13 mA
Power consumption: < 150 mW
Reverse polarity protection

Electrical connection

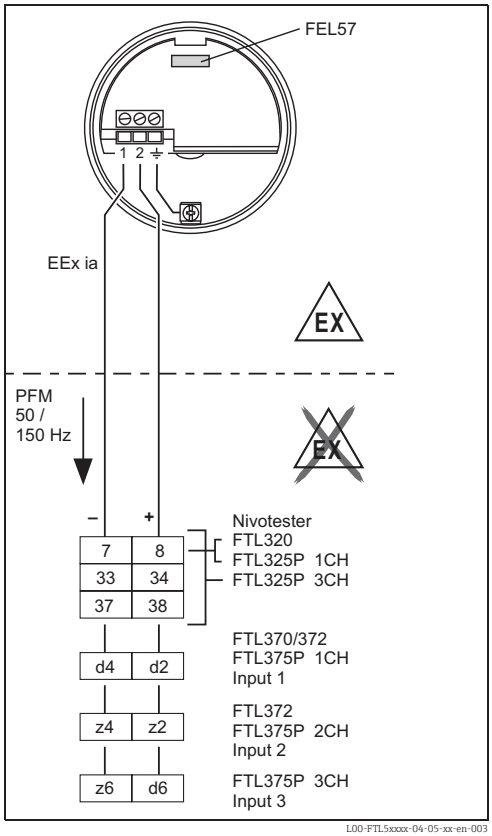
Two-wire connection for separate switching unit

For connecting to Endress+Hauser switching units Nivotester FTL320, FTL325P, FTL370, FTL372, FTL375P (also with proof test).

Output signal jump of the PFM signal from high to low frequency when sensor is covered. Switching between minimum/maximum safety in the Nivotester.

Additional function “proof test”:
After interruption of the power supply, a test cycle is activated which checks the sensor and electronics without any change in level.
Approved for overfill protection acc. to WHG (German Water Resources Act).
The following can be switched at the electronic insert:

- **Standard (STD):**
  Corrosion of the fork unlikely;
  simulation approx. 8 s
  tuning fork exposed – covered – exposed.
  For proof testing, the Nivotester tests the sensor's level notification function.
- **Extended (EXT)**:
  Corrosion of the fork possible;
  Simulation approx. 41 s: tuning fork exposed – covered – corroded – exposed.
  For proof testing, the Nivotester tests the sensor's level notification function and fault notification (alarm) function.

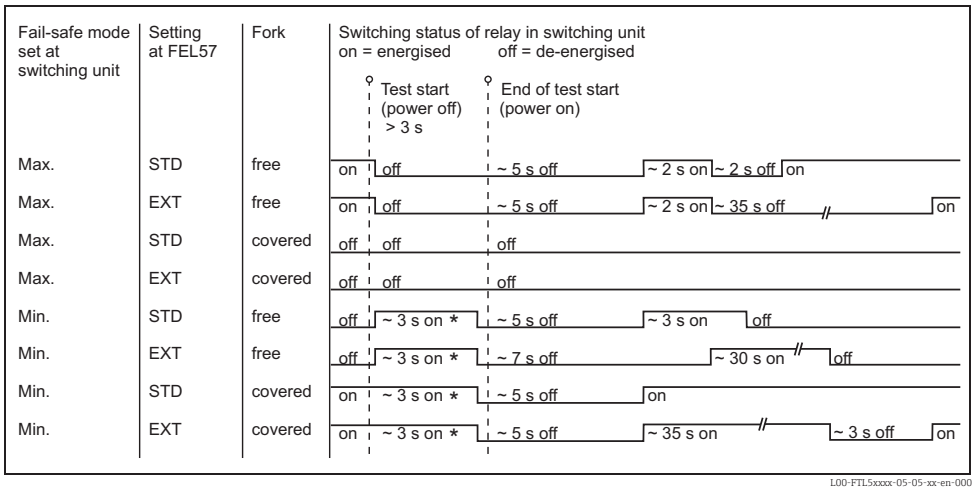


The check is activated and monitored at the switching unit.

The twin-core connecting cable (instrument cable) with a cable resistance of ≤ 25 Ω per core is connected to the screw terminals (conductor cross-sections 0.5 to 2.5 mm / 0.02 to 0.1 in) in the connection compartment. Protective circuits against reverse polarity, HF influences and overvoltage peaks are installed.
Maximum cable length up to 1000 m (3281 ft).

A shielded connecting cable is recommended in the event of strong electromagnetic interference. Here the shielding must be connected to the sensor and the power supply.

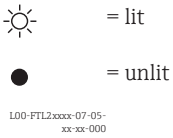
Switching behavior of the connected device:

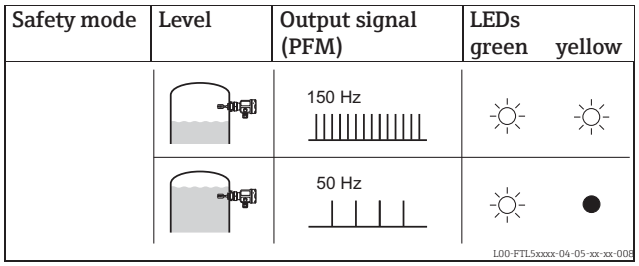


* De-energized on power supply failure

Please note this switching response and function of the plant especially when replacing a Liquiphant incorporating electronic insert EL17Z or FEL37 with a Liquiphant M incorporating electronic insert FEL57.

Output signal





Signal on alarm

Output signal on power failure or in the event of damaged sensor: 0 Hz

Connectable load

- Floating relay contacts in the connected switching unit Nivotester FTL320, FTL325P, FTL370, FTL372, FTL375P
- For contact load, see the Technical Data of the switching unit.

Electronic insert FEL50A (PROFIBUS PA)

Power supply

Bus voltage: DC 9 to 32 V
Bus current:
- 12.5 mA +/– 1.0 mA (software version: 01.03.00, hardware version: 02.00)
- 10.5 mA +/– 1.0 mA (software version: 01.03.00, hardware version: 01.00)

Electrical connection

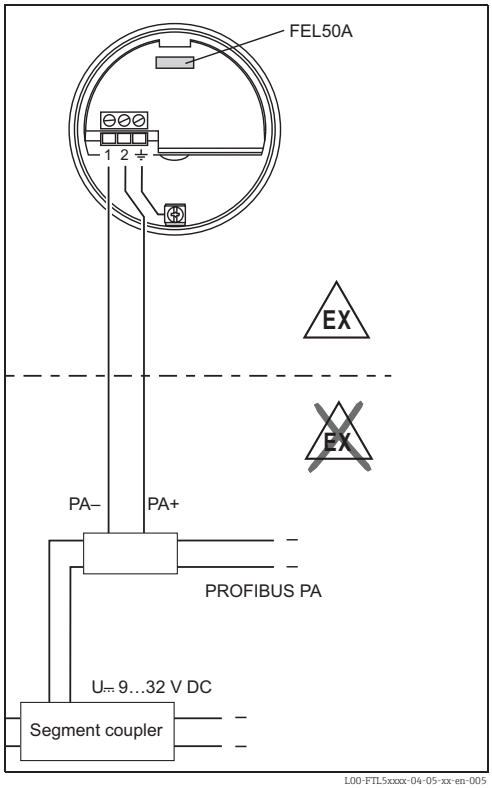
Two-wire connection for power supply and data transfer

For connecting to PROFIBUS PA

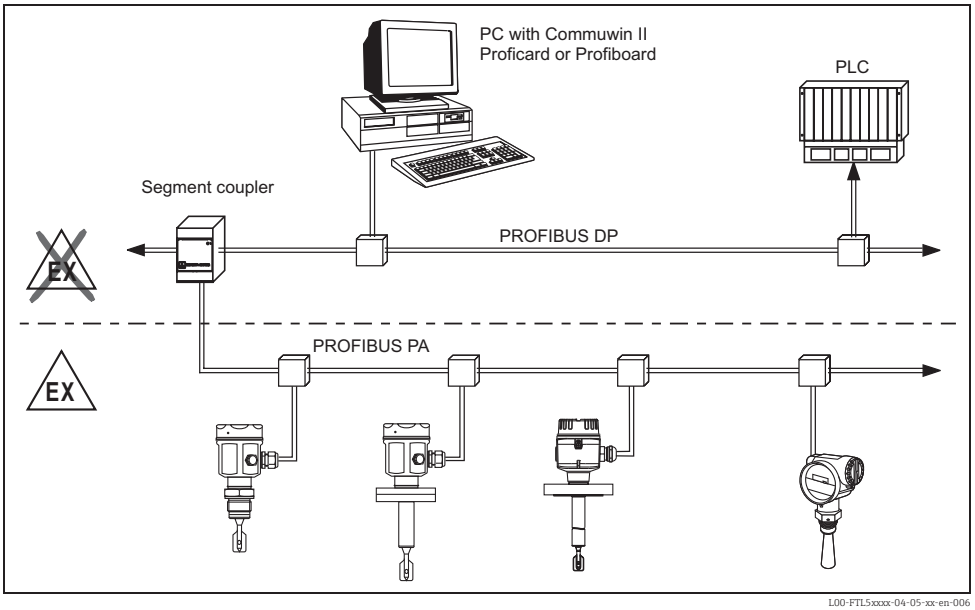
Additional functions:

– Digital communication enables the representation, reading and editing of the following parameters: Fork frequency, switch-on frequency, switch-off frequency, switch-on time and switch-off time, status, measured value, density switch.

– Matrix locking possible
– Switch to WHG mode possible (WHG approval)
– For a detailed description, see BA198F



L00-FTL5xxxx-04-05-xx-en-005



L00-FTL5xxxx-04-05-xx-en-006

Output signal

☼ = lit

● = unlit

L00-FTL2xxxx-07-05-xx-xx-000

Setting	Level	LEDs green	LEDs yellow	FEL50A
not inverted		☼	●	OUT_D = 0 PA bus signal
		☼	☼	OUT_D = 1 PA bus signal
inverted		☼	☼	OUT_D = 0 PA bus signal
		☼	●	OUT_D = 1 PA bus signal

L00-FTL5xxxx-04-05-xx-xx-005

Signal on alarm

- Failure information can be opened using the following interfaces:
  Yellow LED flashing, status code, diagnostic code; see BA00198F

Electronic insert FEL50D (density)

Power supply

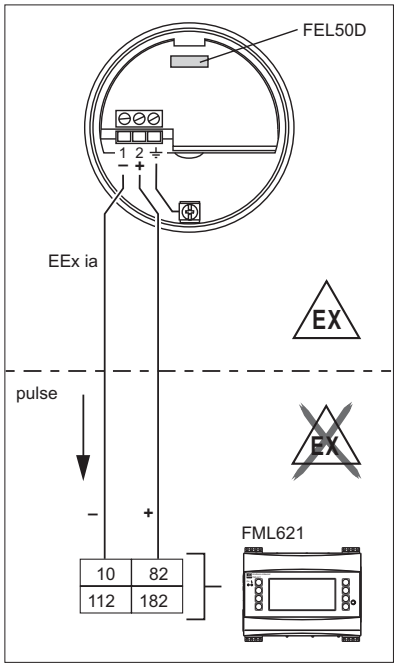
Frequency range: 300 to 1500 Hz
Signal level: 4 mA
Pulse height: 16 mA
Pulse width: 20 µS

Electrical connection

Two-wire connection at Density Computer FML621
For connecting to the density and concentration computer
FML621.

The output signal is based on pulse technology. With the aid of this signal, the fork frequency is constantly
forwarded to the switching unit.

Caution!
Operation with other switching units, such as FTL325P, is not permitted.
This electronic insert cannot be installed in devices that were originally used as a point level switch.



TI420Fen004

Signal on alarm

Output signal on power failure or in the event of damaged sensor: 0 Hz

Adjustment

In the Liquiphant M modular system, the option of an adjustment is also provided in addition to the electronics (see feature 60: "Accessories").

There are three types of adjustment:

Standard adjustment (see ordering information for additional option, basic version A)
- Here, two fork parameters are determined to describe the sensor characteristics, indicated in the adjustment report and provided with the product.
  These parameters must be transmitted to the Density Computer FML621.

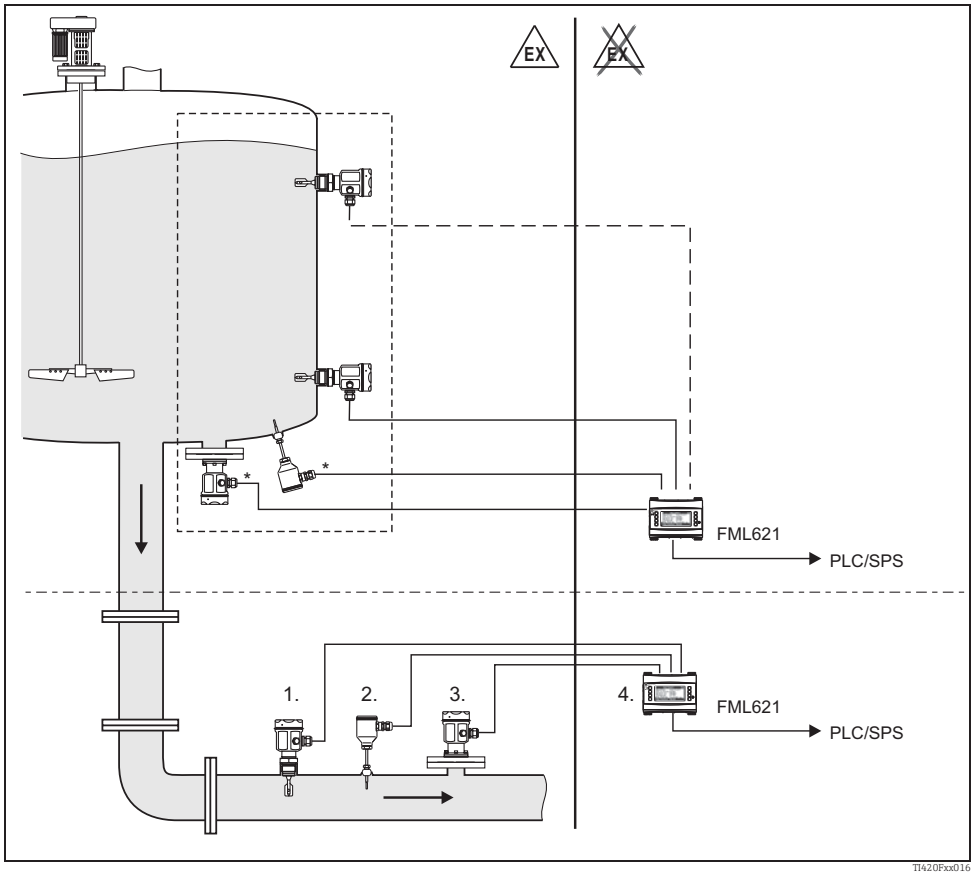
Special adjustment (see ordering information for additional option, special adjustment, density H_2O (K) or special adjustment, density H_2O with 3.1 certificate (L))
- Here, three fork parameters are determined to describe the sensor characteristics, indicated in the adjustment report and provided with the product.
  These parameters must be transmitted to the Density Computer FML621.
  Greater accuracy is achieved with this type of adjustment (see also "Performance characteristics").

Field Adjustment
- During field adjustment, a density value actually determined by the customer is entered and the system is automatically adjusted to this value (wet adjustment).

Note!
More information on Liquiphant M Density is available in Technical Information TI00420F. This can be downloaded from www.endress.com => Download.

Operating principle

Measuring the density of a liquid medium in pipes and tanks. Also suitable for use in hazardous areas, and preferably for applications in the chemical and food industry.



** Pressure and temperature information required depending on the application.*
1. Liquiphant M sensor with electronic insert FEL50D (pulse output);
2. Temperature sensor (e.g. 4 to 20 mA output);
3. Pressure transmitter (4 to 20 mA output);
4. Liquiphant density and concentration computer FML621 with display and operating unit

Light signals

LED	Symbol	Information
Yellow		Measurement valid
		Unstable process situation
		Maintenance required
Green		Power on
		Power off
Red		No fault
		Maintenance required
		Device failure

Connection and function

Connecting cables

- Electronic inserts: cross-section ≤ 2.5 mm² (14 AWG); strand in ferrule as per DIN 46228
- Protective ground in housing: cross-section ≤ 2.5 mm² (14 AWG)
- External equipotential bonding connection on housing: cross-section ≤ 4 mm² (12 AWG)

Safety mode

Minimum/maximum residual current safety selectable on electronic insert.
(with FEL57 on Nivotester only)

MAX = maximum safety:
The output switches to the power fail response when the fork is covered
For use with overfill protection for example

MIN = minimum safety:
The output switches to the power fail response when the fork is exposed
For use with dry running protection for example

Switching time

When fork is covered: approx. 0.5 s
When fork is exposed: approx. 1.0 s
Additionally configurable for PROFIBUS PA:
0.5-60 s

Other switching times available on request.

Switch-on behavior

When switching on the power supply, the output assumes the alarm signal.
After ≤ 3 s it assumes the correct switching mode (exception: FEL57)

Performance characteristics

Reference operating conditions

Ambient temperature: 23 °C (73 °F)

Medium temperature: 23 °C (73 °F)

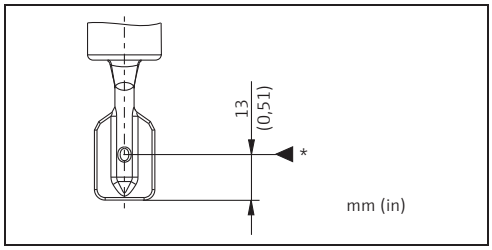
Medium density (water): 1 g/cm³ (SGU)

Medium viscosity: 1 mm²/s (cSt)

Medium pressure p_e: 0 bar (0 psi)

Sensor mounting: vertical from above

Density switch: to > 0.7 g/cm³ (SGU)



** Switch point under reference operating conditions*

Maximum measured error

Under reference operating conditions: max. +/−1 mm (0.04 in)

Repeatability

0.1 mm (0.004 in)

Hysteresis

approx. 2 mm (0.08 in)

Influence of medium temperature

max. +1.8 to −2.8 mm (−50 to +150 °C / -58 to 302 °F)

Influence of medium density

max. +4.8 to −3.5 mm ((0.5 to 1.5 g/cm³ (SGU))
max. +0.19 to -0.14 in

Influence of medium pressure

max. 0 to −2.5 mm (−1 to 64 bar (-14.5 to 928 psi))
max. 0 to -0.1 in

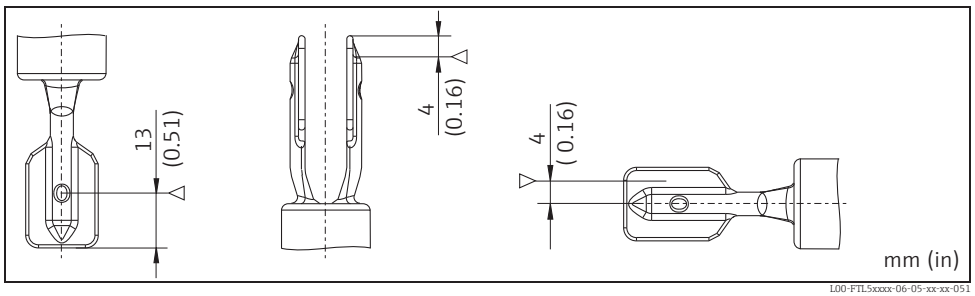
Operating conditions

Installation

Installation instructions

Switch points ▼ on the sensor depend on the mounting position, with reference to water,

Density 1 g/cm³ (SGU), 23 °C (73 °F), p_e 0 bar (0 psi).



Mounting from above *Mounting from below* *Mounting from the side*

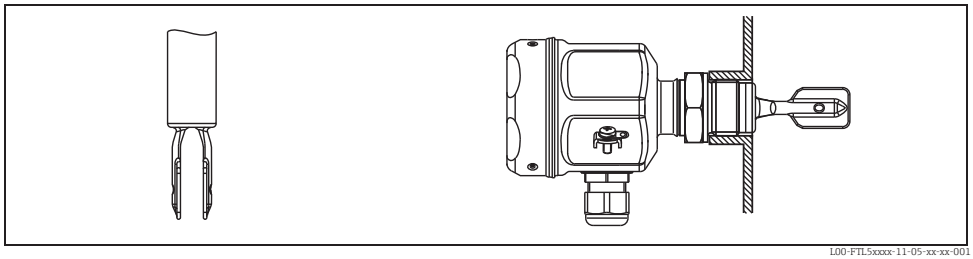
Note!
The switch points of the Liquiphant **M** are at other positions to those of the previous version Liquiphant **II**.

Examples of mounting

Examples of mounting with regard to the viscosity ν of the liquid and the tendency to form buildup

Optimum mounting, without problem even with high viscosity:

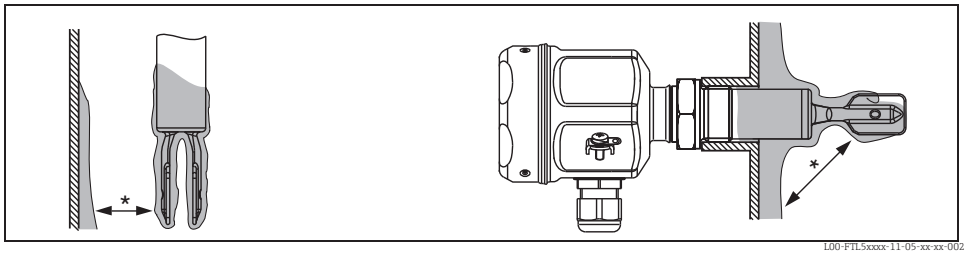
Position the fork so that the narrow edge of the tines is vertical to ensure that the liquid can run off easily.



Vertical from above *Flush-mounted from the side*

With buildup on the tank walls:

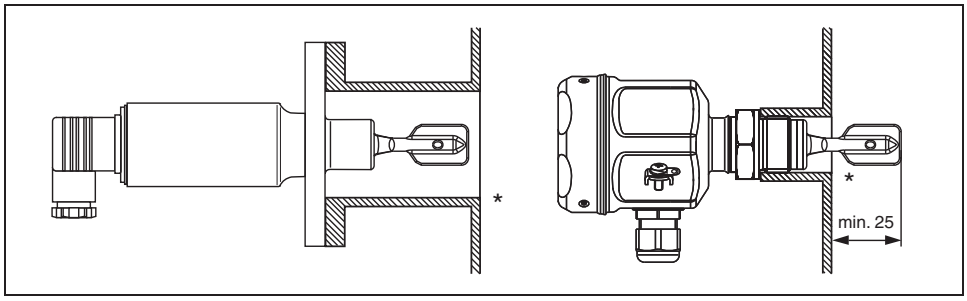
* Ensure that there is sufficient distance between the buildup expected on the tank wall and the fork.



Vertical from above *Protruding into the tank from the side*

Mounting positions in the case of low viscosity up to 2000 mm²/s (cSt):

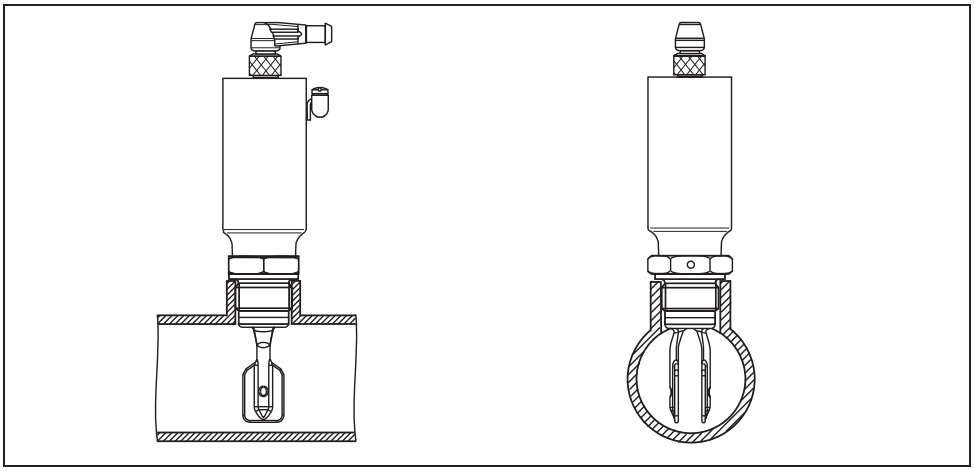
* Deburr the nozzle surfaces



L00-FTL5xxxx-11-05-xx-en-003

Mounting in piping from 2"

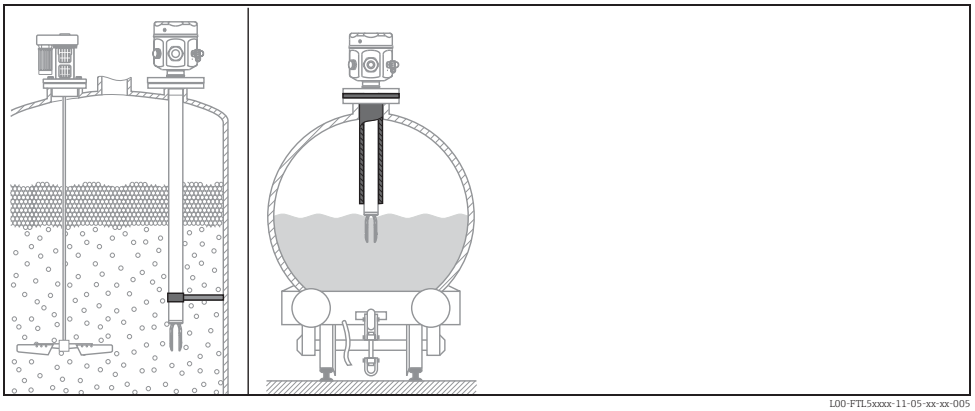
Flow velocities up to 5 m/s for viscosity of 1 mm²/s (cSt) and density 1 g/cm³ (SGU).
(Check the function for other medium conditions.)



L00-FTL5xxxx-11-05-xx-xx-004

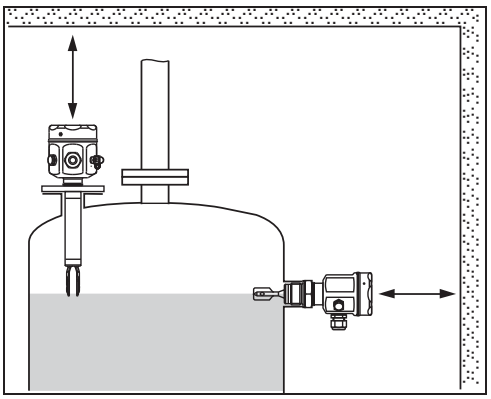
Dynamic load

Support the Liquiphant M FTL51(H) in the event of a severe dynamic load.



L00-FTL5xxxx-11-05-xx-xx-005

Ensure adequate space outside the tank for mounting, connection and configuration.



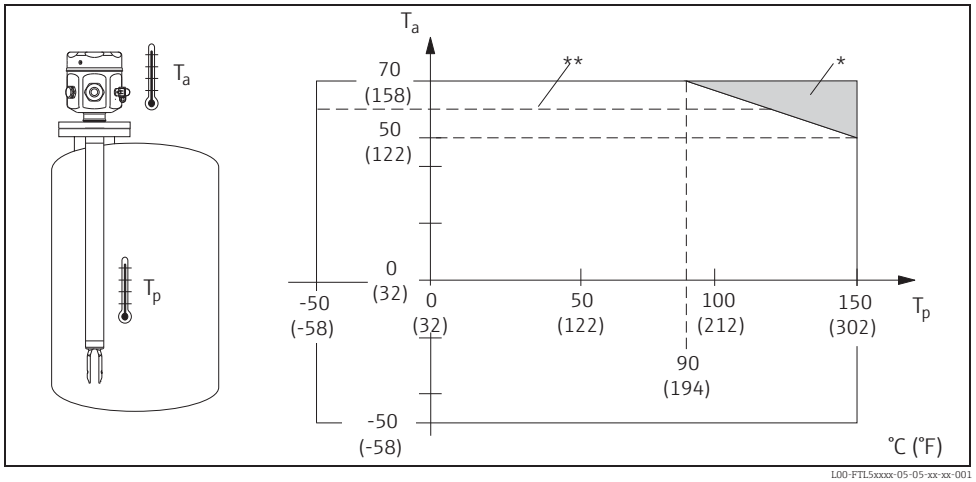
Orientation

- FTL50(H) and FTL51(H) with short pipe up to approx. 500 mm (19.7 in): any position
- FTL51(H) with long pipe: vertical

Environment

Ambient temperature range

Permitted ambient temperature T_a at the housing depending on the medium temperature T_p in the tank:



* Additional temperature range for devices with a temperature spacer or pressure-tight feedthrough.
** Maximum ambient temperature with FEL50D/FEL50A in hazardous areas.

Storage temperature

−50 to +80 °C (-58 to 176 °F)

Installation height as per IEC61010-1 Ed.3

Up to 2000 m (6600 ft) above sea level.

Can be extended up to 3000 m (9800 ft) above sea level if overvoltage protection is used, for example HAW562 or HAW569.

Climate class

Climate protection to IEC 68, Part 2-38, Fig. 2a

Degree of protection

Types of housing	IP65	IP66*	IP67*	IP68*	IP69k	NEMA type**
Compact housing with valve connector Pg11/NPT ½	X	–	–	–	–	–
Compact housing with 5 m (16 ft) cable tail	–	X	–	X	–	–
Compact housing with M12x1 connector (52010285) 316L (metal)	–	X	–	X	–	–
Compact housing with elbowed connector (52024216) / L= 5 m (16 ft), without integrated LEDs	–	X	–	X	X	–
Compact housing with elbowed connector (52018763) / L= 5 m (16 ft), with integrated LEDs	–	X	–	X	X	–
Polyester housing F16	–	X	X	–	–	4X
Stainless steel housing F15	–	X	X	–	–	4X
Aluminum housing F17	–	X	X	–	–	4X
Aluminum housing F13****	–	X	–	X***	–	4X/6P
Stainless steel housing F27	–	X	–	X	–	4X/6P
Aluminum housing T13 with separate connection compartment (Ex d)	–	X	–	X***	–	4X/6P

* As per EN60529
** As per NEMA 250
*** only with M20 cable entry or G1/2 thread
**** F13 housing only in conjunction with XP or Ex d approval

Vibration resistance

As per IEC 68, parts 2-6 (10 to 55 Hz, 0.15 mm (0.01 in), 100 cycles)
In the event of increased vibrations, the following additional option is recommended: feature "060" version "P" 100 bar (1450 psi) process pressure.

Electromagnetic compatibility

Interference emission to EN 61326, Electrical Equipment Class B
Interference immunity to EN 61326; Annex A (Industrial) and NAMUR Recommendation NE 21 (EMC)

Medium conditions

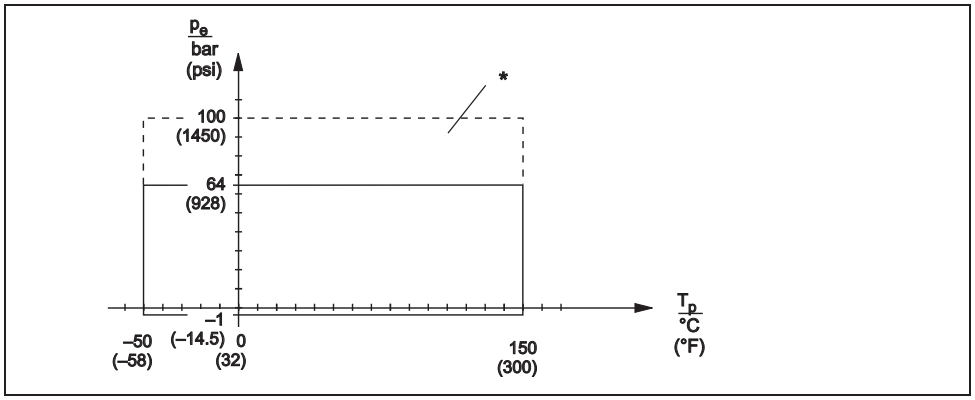
Medium temperature

−50 to +150 °C (-58 to 302 °F); for exceptions, see "Process connections"

Thermal shock

≤ 120 °C/s (248 °F/s)

Medium pressure p_e



L00-FTL5xxxx-05-05-xx-xx-003

* Permitted pressure rating when the "100 bar (1450 psi)" option is selected (see "Product structure FTL51", feature 060, from → 43).
See "Process connections" → 33 for exceptions.
Canadian CRN approval: Additional details on maximum pressure values are available in the download area of the product page at "www.endress.com".

Please refer to the standards listed for the permitted pressure values of the flanges at higher temperatures:

- pR EN 1092-1: 2005
  With regard to their stability-temperature property, the materials 1.4435 and 1.4404 are identical and are grouped together in EN 1092-1 Tab. 18 under 13E0. The chemical composition of the two materials can be identical.
- ASME B 16.5 - 2013 Tab. 2-2.2 F316
- ASME B 16.5 - 2013 Tab. 2-3.8 N10276
- JIS B 2220

The lowest value from the derating curves of the device and selected flange applies in each case.

Test pressure

p_e = 64 bar (928 psi):
- ≤ 100 bar (1450 psi) or 1.5 times the medium pressure p_e
- Sensor burst pressure at 200 bar (2900 psi)

p_e = 100 bar (1450 psi):
- ≤ 150 bar (2175 psi) or 1.5 times the medium pressure p_e)
- Sensor burst pressure at 400 bar (5800 psi)

Note!
The device function is restricted during pressure testing.

State of aggregation

Liquid

Density

0.7 g/cm³ (SGU) = delivery status

0.5 g/cm³* (SGU) can be adjusted via switches

* Density settings for the compact housing on request

Viscosity

≤ 10,000 mm²/s (cSt)

Solids content

≤ ø5 mm (0.2 in)

Lateral loading capacity

≤ 75 Nm

Mechanical construction

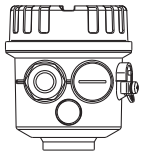
Design

Summary of all electrical and mechanical versions

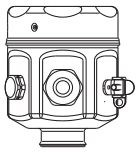
Housing


L00-FTL5xxxx-03-05-xx-xx-019

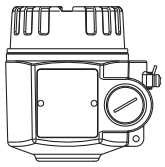
Compact
Pipe housing (316L)


L00-FTL5xxxx-03-05-xx-xx-001

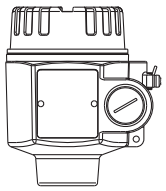
F16
Polyester (PBT)


L00-FTL5xxxx-03-05-xx-xx-002

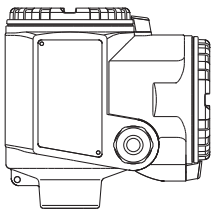
F15
Stainless steel (316L)


L00-FTL5xxxx-03-05-xx-xx-031

F17
Aluminum
Housing coated


L00-FTL5xxxx-03-05-xx-xx-033

F27
Stainless steel (316L)
F13
Aluminum
(also for Ex d/XP),
housing coated


L00-FTL5xxxx-03-05-xx-xx-004

T13
Aluminum with separate connection compartment (also Ex de and Ex d), housing coated

Plug-in electronic inserts to mount in the housing

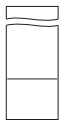

L00-FTL5xxxx-03-05-xx-xx-000

FEL51*:	Two-wire AC connection
FEL52*:	Three-wire DC connection PNP
FEL54:	Universal current connection, 2 relay outputs
FEL55:	Output 16/8 mA for separate switching unit
FEL56:	Output 0.6 to 1.0 / 2.2 to 2.8 mA for separate switching unit (NAMUR)
FEL58*:	Output 2.2 to 3.5 / 0.6 to 1.0 mA for separate switching unit (NAMUR)
FEL57:	Output 150/50 Hz, PFM, for separate switching unit (Nivotester)
FEL50A:	Digital communication PROFIBUS PA
FEL50D:	Pulse output for Density Computer FML621

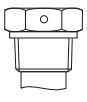
* Electronics also available as compact housing. The electronics cannot be exchanged!

*Bushing*s (optional)

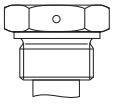
Temperature spacer and pressure-tight feedthrough


L00-FTL5xxxx-03-05-xx-xx-005

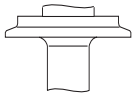
Process connections


L00-FTL5xxxx-03-05-xx-xx-006

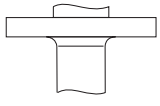
G ¾, DIN ISO 228/I
R ¾, EN10226
NPT ¾, ASME B 1.20.1
(AF 32)


L00-FTL5xxxx-03-05-xx-xx-007

G 1, DIN ISO 228/I
R 1, EN10226
NPT 1, ASME B 1.20.1
(AF 41)

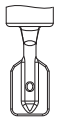
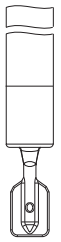
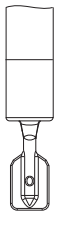

L00-FTL5xxxx-03-05-xx-xx-008

Diverse
hygienic and
aseptic
connections


L00-FTL5xxxx-03-05-xx-xx-009

Flanges as per DIN,
ASME,
JIS
from DN 25 / 1"

Sensors

Compact, with extension pipe up to 3 m (up to 6 m on request) or special "length L II" (see → 33ff.)	Compact	Length L II	Length L
			
p_e = bar/psi	64/928	64/928 100/1450	64/928 100/1450

L00-FTL5xxxx-03-05-xx-xx-018

Dimensions

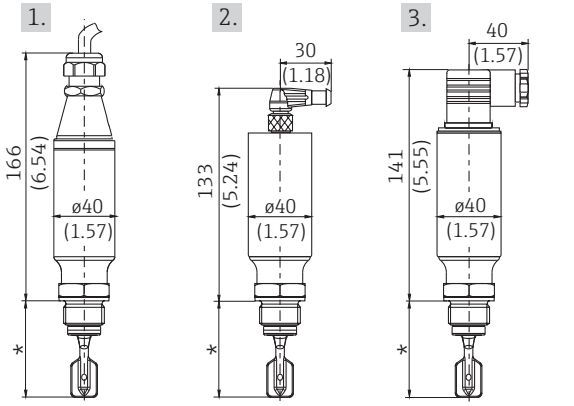
Dimensions in mm (in)!

Housing FTL50(H), FTL51(H) with sensor FTL50(H)

Compact housing, primarily for hygiene applications

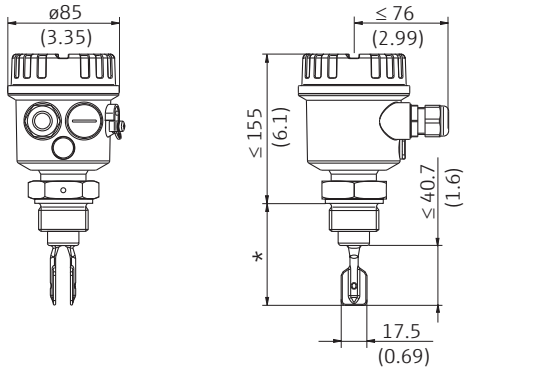
c

1. 5 m cable
2. M12 connector
3. Pg11/NPT ½ connector



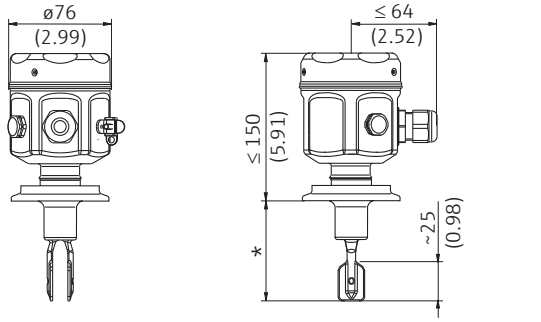
L00-FTL5xxxx-06-05-xx-xx-085

Polyester housing F16



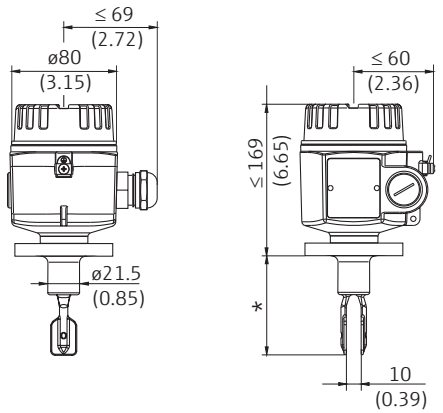
L00-FTL5xxxx-06-05-xx-xx-086

F15 stainless steel housing primarily for hygiene applications



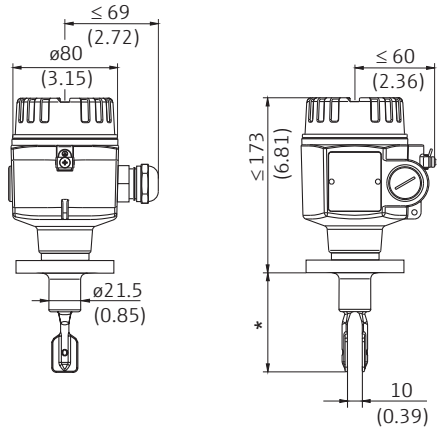
L00-FTL5xxxx-06-05-xx-xx-087

Aluminum housing F17



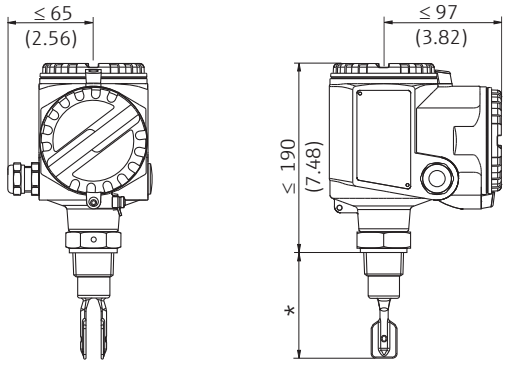
L00-FTL5xxxx-06-05-xx-xx-088

Stainless steel housing (316L) F27
Aluminum housing F13



L00-FTL5xxxx-06-05-xx-xx-089

Aluminum housing T13
with separate connection compartment



L00-FTL5xxxx-06-05-xx-xx-090

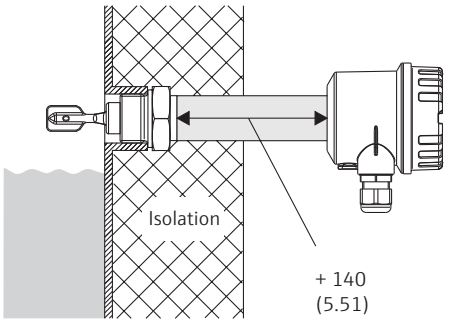
* See "Process connections"

Note!
The switch points of the Liquiphant **M** are at other positions to those of the previous version Liquiphant **II**.

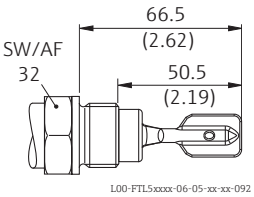
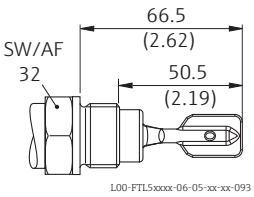
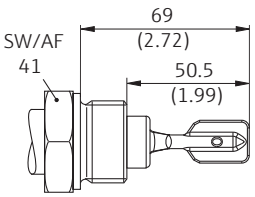
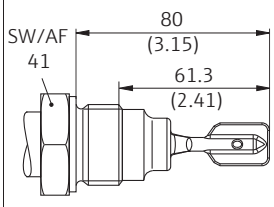
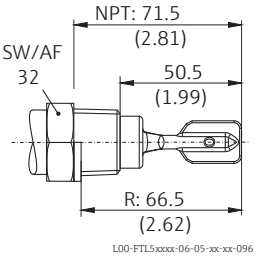
Bushings: temperature spacer, pressure-tight feedthrough

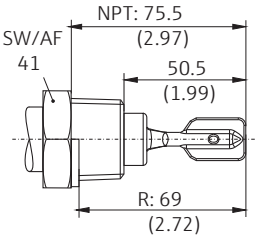
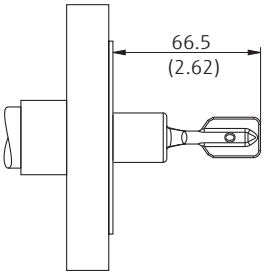
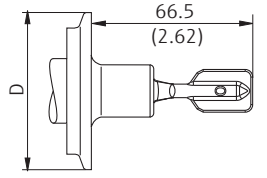
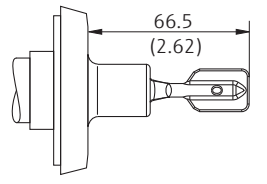
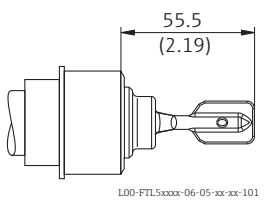
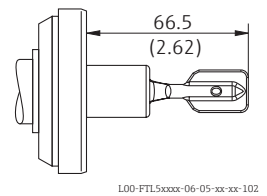
Temperature spacer
Provides sealed insulation for the vessel and normal ambient temperatures for the housing.

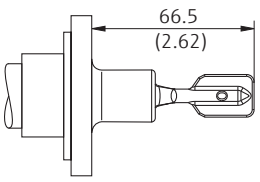
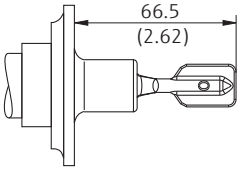
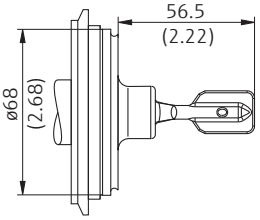
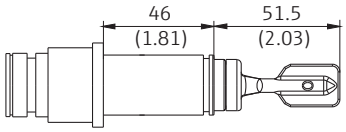
Pressure-tight feedthrough
Protects the housing from pressures up to 100 bar (1450 psi) if the sensor is damaged. Provides sealed insulation for the vessel and normal ambient temperatures for the housing.



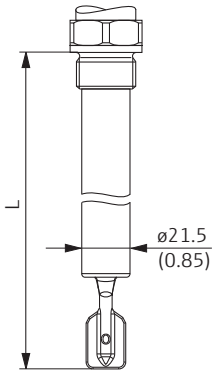
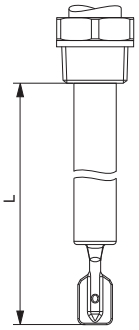
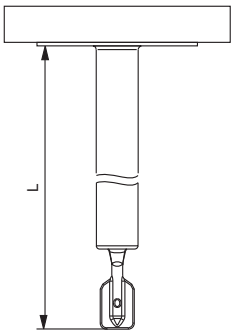
Process connections for FTL50(H) and FTL51(H)

Process connection		Dimensions	Accessories	Pressure Temperature
G ¾ DIN ISO 228/l with defined thread start; Flat seal to DIN 7603: supplied	GQ2 GQ6			≤ 100 bar / only FTL51 (≤ 1450 psi) ≤ 150 °C (302 °F)
G ¾ DIN ISO 228/l with defined thread start for flush-mounted installation in weld-in adapter	GQ2 GQ6		**Weld-in adapter** (with defined thread start) with silicone O-ring only FTL50, FTL50H See "Accessories" In conformity with FDA*	≤ 25 bar (363 psi) ≤ 150 °C (302 °F) ≤ 40 bar (580 psi) ≤ 100 °C (212 °F)
G 1 DIN ISO 228/l Flat seal to DIN 7603: supplied	GR2 GR6			≤ 100 bar / only FTL51 (1450 psi) ≤ 150 °C (302 °F)
G 1 DIN ISO 228/l with defined thread start With seal surface for flush-mounted installation in weld-in adapter	GW2		**Weld-in adapter** (with defined thread start) with silicone O-ring See "Accessories" In conformity with FDA*	≤ 25 bar (363 psi) ≤ 150 °C (302 °F) ≤ 40 bar (580 psi) ≤ 100 °C (212 °F)
NPT ¾ ASME B 1.20.1 or **R ¾** DIN/EN 10226	GM2 GM6 GE2 GE6			≤ 100 bar / only FTL51 (1450 psi) ≤ 150 °C (302 °F)

Process connection		Dimensions	Accessories	Pressure Temperature
NPT1 ASME B 1.20.1 or **R 1** DIN/EN 10226	GN2 GN6 GF2 GF6			≤ 100 bar / only FTL51 (1450 psi) ≤ 150 °C (302 °F)
* FDA-compliant material in accordance with 21 CFR Part 177.2600 (silicone)				
Flanges ASME B 16.5 EN 1092-1 (DIN 2527 B) JIS B2220	A## B## C## F## N## K##		Seal depending on design installed on site	See nominal pressure of flange, however ≤ 100 bar (1450 psi) (only FTL51) ≤ 150 °C (302 °F)
	For higher chemical-resistance, AlloyC22-plated flanges are available. The flange carrier material is made of 316L and is welded with a 2 to 3 mm (0.08 to 0.12 in) thick AlloyC22 disk.			
Tri-Clamp ISO 2852 DN25-38 (1 to 1 ½") DIN 32676 DN25-40 ø D = 50.5 mm (1.99 in) ISO 2852 DN40-51 (2") DIN 32676 DN50 ø D = 64.0 mm (2.52 in)	TC2 TE2		Clamping ring and front seal installed on site**	≤ 25 bar (363 psi) ≤ 150 °C (302 °F)
	Mounting with NA connector only in conjunction with T13, F13 and compact housing. Other housings on request.			
Threaded pipe joint DN 32 DN 40 DN 50 DIN 11851 with thread adapter nut	MA2 MC2 ME2		Sealing ring with collar, installed on site**	DN 32, DN 40: ≤ 40 bar (580 psi) up to 100 °C (212 °F) ≤ 25 bar (363 psi) up to 140 °C (284 °F) DN 50: ≤ 25 bar (363 psi) ≤ 140 °C (284 °F)
Flush-mounted for weld-in adapter Factory standard Endress+Hauser with silicone seal and thread adapter nut: supplied	EE2		**Weld-in adapter** (fork can be positioned) See "Accessories" In conformity with FDA*	≤ 40 bar (580 psi) ≤ 100 °C (212 °F) ≤ 25 bar (363 psi) ≤ 150 °C (302 °F)
Aseptic DN 50 DIN 11864-1 Form A for pipe DIN 11850 with thread adapter nut	HE2		sealing ring installed on site**	≤ 25 bar (363 psi) ≤ 140 °C (284 °F)

Process connection		Dimensions	Accessories	Pressure Temperature
DRD With clamped flange	PE2	 L00-FTL5xxxx-06-05-xx-xx-103	Welding flange with PTFE flat seal (fork can be positioned) See "Accessories" (or installed on site)** In conformity with FDA*	≤ 40 bar (580 psi) ≤ 100 °C (212 °F) ≤ 25 bar (363 psi) ≤ 150 °C (302 °F)
* FDA-compliant material in accordance with 21 CFR Part 177/2600 (silicone), 21 CFR Part 177.1550 (PTFE) ** The maximum temperature and the maximum pressure are dependent on the clamping ring used and the seal used. The lowest value applies in each case.				
SMS 2" (DN 51) with thread adapter nut	UE2	 L00-FTL5xxxx-06-05-xx-xx-104	sealing ring installed on site**	≤ 25 bar (363 psi) ≤ 140 °C (284 °F)
Varivent for piping ≥ DN 65 ≥ O.D. 3" ≥ I.P.S. 3"	WE2	 L00-FTL5xxxx-06-05-xx-xx-105	Clamping ring and O-ring seal, installed on site**	However, see specification as per Tuchenhagen VARIVENT-Inline housing: ≤ 25 bar (363 psi) ≤ 150 °C (302 °F)
Ingold fitting DN 25 Fitting length 46 mm (2.52 in) Thread adapter nut G 1 ¼ with O-ring seal, EPDM (FDA-compliant, USP Class VI*)	TT2	 L00-FTL5xxxx-06-05-xx-xx-106		≤ 16 bar (232 psi) ≤ 150 °C (302 °F)
* FDA-compliant material in accordance with 21 CFR Part 177/2600 (EPDM) ** The maximum temperature and the maximum pressure are dependent on the clamping ring used and the seal used. The lowest value applies in each case.				

Sensor length L for FTL51 and FTL51H, depending on process connection

Thread: G ¾, G 1	Thread: NPT ¾, NPT1, R ¾, R 1	Flanges and flange-like process connections
 L00-FTL5xxxx-06-05-xx-xx-107	 L00-FTL5xxxx-06-05-xx-xx-017	 L00-FTL5xxxx-06-05-xx-xx-018
From seal surface of thread adapter	From lower edge of thread	

Customized length L:
- 148 mm to 3000 mm (6 to 115in); special version (TSP) on request up to 6000 mm (235 in)
- Length tolerances L: < 1 m (–5 mm), 1 to 3 m (–10 mm) / < 3.3 ft (-0.2 in), 3.3 to 9.8 ft (-0.39 in)

Note!
The switch points of the Liquiphant M are at other positions to those of the previous version Liquiphant **II**.
Special length "L II":
With vertical mounting from above the same switch point as for the Liquiphant II
FTL360, FTL365, FDL30, FDL35

"L II" depends on process connection:

L = 115 mm (4.53 in) for flanges and flange-like process connections
L = 99 mm (3.9 in) for threads NPT and R (BSPT)
L = 118 mm (4.65 in) for threads G1 (BSP 1)
L = 115 mm (4.53 in) for threads G ¾ (BSP ¾)
L = 104 mm (4.09 in) for flush-mounted 1" (Endress+Hauser)

Weights

See "Ordering information" → 43ff

Materials and surfaces

Material specifications as per AISI and DIN-EN.

Parts in contact with process

- Process connection and extension pipe:
  - FTL5x → 316L (1.4404 or 1.4435) optional 2.4602 (AlloyC22)
  - FTL5xH → 316L (1.4435)
- Tuning fork: 316L (1.4435) optional 2.4602 (AlloyC22)
- Flanges: 316L (1.4404)
- Flange plating: AlloyC22
- Flat seal for process connection G ¾ or G 1: elastomer fiber, asbestos-free

Surface roughness

Choice of mechanically polished surface roughness (version → probe length → type):

- Ra < 1.5 µm (59.1 µin), with EHEDG approval
- Ra < 0.3 µm (11.8 µin), 3-A and EHEDG approval and CoC-ASME-BPE

Note!
The surface is electropolished if the additional option "B"
(CoC - ASME BPE) is selected in addition to surface roughness quality Ra < 0.3 µm (11.8 µin). The

surface roughness is then: Ra < 0.38 µm (15.0 µin).
With this combination, the wetted parts are made of 316L (1.4435) in accordance with BN2 (delta-ferrite content < 1 %).

Parts with no process contact

- Tuning fork/housing seal: EPDM
- Temperature spacer: 316 L (1.4435)
- Pressure-tight feedthrough: 316L (1.4435)
- Ground terminal on housing (external): 316L (1.4404)
- Cable glands
  - Housing F13, F15, F16, F17: polyamide (PA)
    With B or C approval (→ 📄 43 ordering information): nickel-plated brass
  - Housing F27: polyamide PA, with approval "B" or "C" 316L (1.4435)
  - Housing T13: nickel-plated brass
- Polyester housing F16: PBT-FR with PBT-FR cover or with PA12 transparent cover
  - Cover seal: EPDM
  - Nameplate glued: polyester film (PET)
  - Pressure compensation filter: PBT-GF20
- Stainless steel housing F15: 316L (1.4404)
  - Cover seal: silicone
  - Safety claw: 304 (1.4301)
  - Pressure compensation filter: PBT-GF20, PA
- Aluminum housing F17/F13: EN-AC-AlSi10Mg, plastic-coated
  - Nameplate: aluminum, anodized
  - Cover seal: EPDM
  - Safety claw: nickel-plated brass
  - Pressure compensation filter: silicone
- Stainless steel housing F27: 316L
  - Nameplate: 316L (1.4404)
  - Cover seal: FVMQ (optional: EPDM seal available as spare part)
  - Safety claw: 316L (1.4435)
- Aluminum housing T13: EN-AC-AlSi10Mg, plastic-coated,
  - Nameplate: aluminum, anodized
  - Cover seal: EPDM
  - Safety claw: nickel-plated brass
- Compact housing (valve connector or M12 connector): 316L (1.4435)

Process connections

- Parallel thread G ¾, G 1 to DIN ISO 228/I with flat seal to DIN 7603
- Tapered thread R ¾, R 1 to EN10226
- Tapered thread ¾ -14 NPT, 1 - 11½ NPT as per ASME B 1.20.1
- Flush-mounted installation with weld-in adapter to factory standard Endress+Hauser (G ¾, G 1)
- Flush-mounted installation with weld-in adapter to factory standard Endress+Hauser (1"), sensor can be positioned
- Tri-Clamp 1½", 2" to ISO 2852
- Threaded pipe joint DN 32, 40, 50 to DIN 11851
- Aseptic connection DN 50 to DIN 11864-1
  Form A for pipe DIN 11850
- SMS connection 2" (DN 51)
- DRD flange
- Varivent® DN 50 (50/40) to factory standard Tuchenhagen
- Flanges: as per EN/DIN 1092-1 from DN 25, as per ASME B 16.5 from 1", as per JIS B2220 (RF)
- Ingold DN25 fitting length 46 mm (1.81 in) with thread adapter nut G1 ¼

Further details at Ordering information → 📄 43.

Human interface

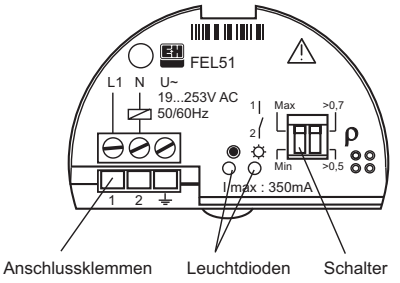
Electronic inserts

With FEL51, FEL52, FEL54, FEL55:

- 2 switches for safety mode and density change
- green LED to indicate operational status
- red LED to indicate the switching status, flashes in the event of corrosion damage on sensor or if the electronics are defective

With FEL56:

- 2 switches for safety mode and density change
- green LED flashes to indicate operational status
- red LED to indicate the switching status, flashes in the event of corrosion damage on sensor or if the electronics are defective



L00-FTL5xxxx-03-05-xx-en-001

With FEL57:

- 2 switches for density change and Testing
- green LED to indicate operational status
- yellow LED to indicate the covered status, flashes in the event of corrosion damage on sensor or if the electronics are defective

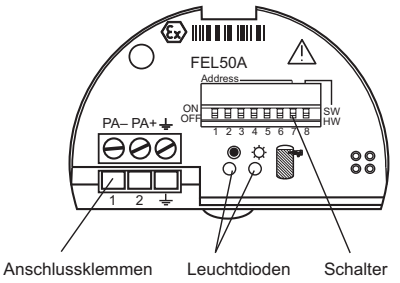
L00-FTL5xxxx-03-05-xx-xx-013

With FEL58:

- 2 switches for safety mode and density change
- green LED
  - flashes quickly to indicate operational status,
  - flashes slowly in the event of corrosion damage to the sensor of if the electronics are defective
- yellow LED to indicate the switching status, Test key – breaks the cable connection

With FEL50A:

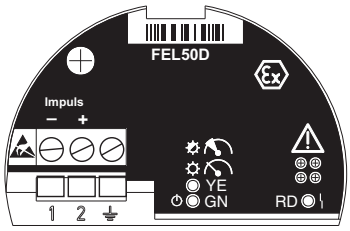
- 8 switches for configuring the device address
- green LED to indicate operational status, pulsing to indicate communication;
- yellow LED to indicate the switching status, flashes in the event of corrosion damage on sensor or if the electronics are defective



L00-FTL5xxxx-03-05-xx-en-002

With FEL50D:

- yellow LED: to indicate the validation of the measurement
- green LED: to indicate the operational status
- red LED: to indicate faults



TI328Fxx004

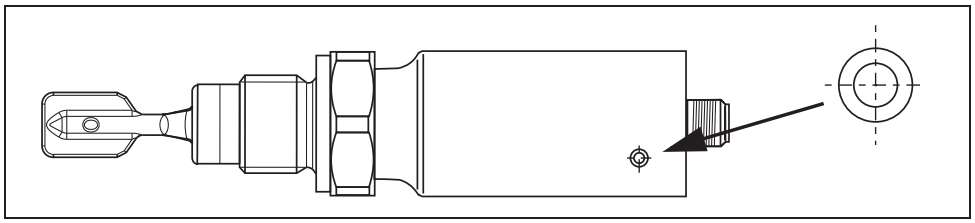
Compact housing

Function test with test magnet

Versions AC, DC-PNP and NAMUR:

During the test, the current state of the electronic switch is reversed.

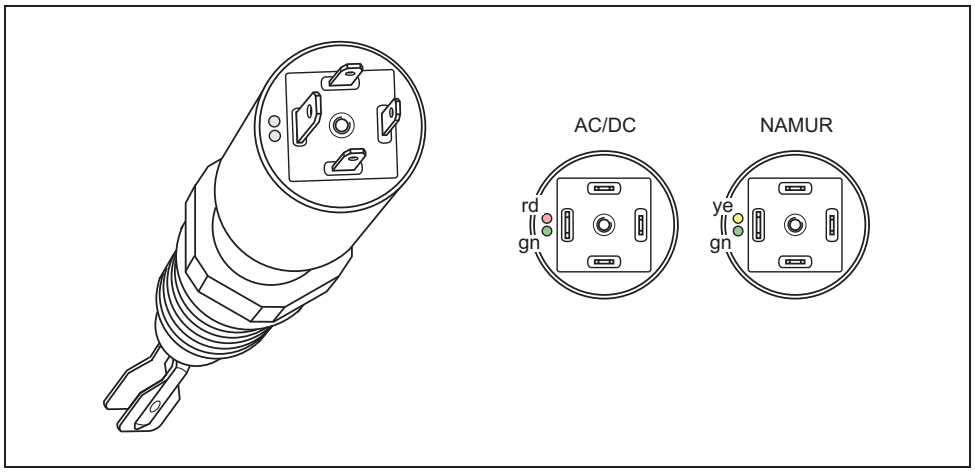
Hold the test magnet against the marking on the nameplate: The switching status is changed.



L00-FTL5xxxx-19-05-xx-xx-001

Light signals

Versions AC and DC-PNP with valve connector or cable tail



L00-FTL5xxxx-07-05-xx-xx-005

Green light (gn) lights up (AC/DC):

Liquiphant M is connected to the power supply and is operational.

Green light (gn) flashing (NAMUR):

Liquiphant M is connected to the power supply and is operational.

Red light (rd) lights up (AC/DC):

MAX application mode (overfill protection): sensor is immersed in liquid.
MIN application mode (dry running protection): sensor is not immersed in liquid.

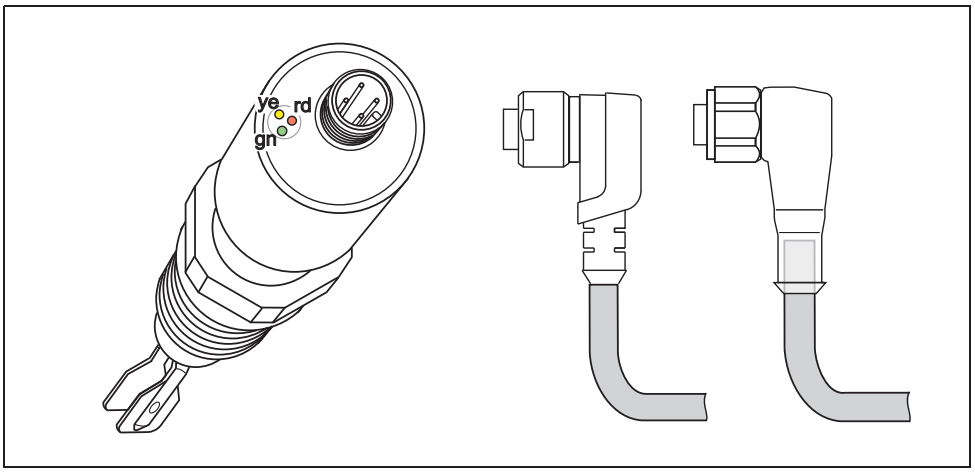
Yellow light (ye) lights up (NAMUR):

MAX application mode (overfill protection): sensor is not immersed in liquid.
MIN application mode (dry running protection): sensor is immersed in liquid.

Red light (rd) flashing (AC/DC):

Liquiphant M has detected a fault.

Version NAMUR and DC-PNP with M12x1 round connector 316L



L00-FTL5xxxx-07-05-xx-xx-003

Green light (gn) lights up (DC-PNP):

Liquiphant M is connected to the power supply and is operational.

Green light (gn) flashing with 1 Hz (NAMUR):

Liquiphant M is connected to the power supply and is operational.

Yellow light (ye) lights up (DC-PNP):

Sensor is immersed in liquid.

Yellow light (ye) lights up (NAMUR):

MAX application mode (overfill protection): sensor is not immersed in liquid.
MIN application mode (dry running protection): sensor is immersed in liquid.

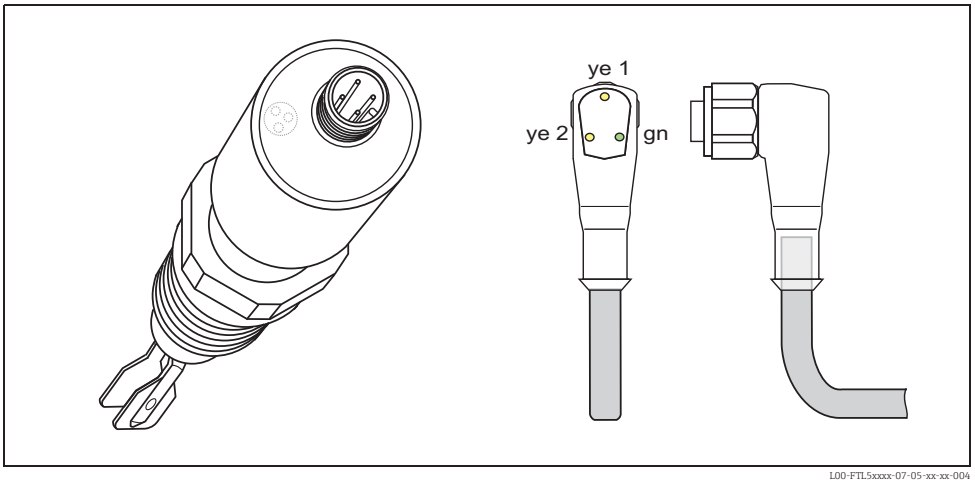
Red light (rd) flashing (DC-PNP):

Liquiphant M has detected a fault.

Green light (gn) flashing with 0.3 Hz (NAMUR):

Liquiphant M has detected a fault.

Version DC-PNP with M12x1 round connector 316L



L00-FTL5xxxx-07-05-xx-xx-004

Green light (gn) lights up:

Liquiphant M is connected to the power supply and is operational.

Yellow light (ye 1) lights up:

MAX application mode (overfill protection): sensor is not immersed in liquid.
MIN application mode (dry running protection): sensor is not immersed in liquid.

Yellow light (ye 2) lights up:

MAX application mode (overfill protection): sensor is immersed in liquid.
MIN application mode (dry running protection): sensor is immersed in liquid.

Green light (gn) lights up, both yellow lights (ye 1+2) do not light up:

Liquiphant M has detected a fault.

Operating concept

Onsite configuration

Certificates and approvals

CE mark

The measuring system meets the legal requirements of the applicable EC Directives. These are listed in the corresponding EC Declaration of Conformity along with the standards applied.
Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.

C-tick mark

The measuring system complies with the EMC requirements of the "Australian Communications and Media Authority (ACMA)".

General approvals

The following approvals are available for Liquiphant M FTL50H, FTL51H:

- EHEDG: certification (from TNO, The Netherlands), Report No. V99.394:
- 3A: 3A certificate (USA), Authorization no. 459: 74-06 Sensors and Sensor Fittings and Connections
- Certificate of Compliance as per ASME BPE-2012. (Order code: additional option = B)

Process connections	Order code	EHEDG + 3A		ASME BPE + CoC	
				Ra (µm)	
				< 0.38	< 1.5
Thread ISO228 G3/4, 316L, installation Thread ISO228 G1, 316L, installation Accessories: weld-in adapter	GQ2 GW2	X	X	–	X
Tri-Clamp ISO2852 DN25-38 (1 to 1-1/2"), 316L Tri-Clamp ISO2852 DN40-51 (2"), 316L	TC2 TE2	X	X	X	X
DIN11851 DN32 PN25 slotted nut, 316L DIN11851 DN40 PN25 slotted nut, 316L DIN11851 DN50 PN25 slotted nut, 316L	MA2 MC2 ME2	X	X	X	X
Flush-mounted, 316L, installation Accessories, weld-in adapter	EE2	X	X	X	X
DIN11864-1 A DN50 pipe DIN11850, Slotted nut, 316L	HE2	X	X	X	X
DRD 65mm, 316L	PE2	X	–	–	X
SMS 2" PN25, 316L	UE2	X	X	X	X
Varivent N pipe DN65-162 PN10, 316L	WE2	X	X	X	X
Ingold fitting 25x46mm, 316L	TT2	–	–	X	–

Warning!
To avoid risk of contamination, install according to the "Hygienic Equipment Design Criteria (HDC)" as stated in the Subgroup Design Principles of the EHEDG, Doc. 8, July 1993.
The flow of liquid during cleaning is important and should be in compliance with the HDC.

Note!
- For CIP (Clean in Place) and SIP (Sterilize in Place) processes the pressure and temperature specifications of the process connections must be observed.
- Suitable fittings and seals must be used to ensure hygiene-compliant design according to 3A, EHEDG, ASME BPE etc.
- Surfaces with ASME-BPE option: Ra < 0.38 µm (< 15 µin) electropolished and passivated or Ra < 1.5 µm (59 µin) mechanically polished.

CRN approval

Versions with a CRN approval (Canadian Registration Number) are marked with a "*" in ordering information feature 20 "process connection" (s. Seite 43 ff.). CRN-approved devices are assigned the registration number 0F10525.5C on the nameplate.

Process seal according to ANSI/ISA 12.27.01

Practice in North America for the installation of process seals
Endress+Hauser devices are designed as either single seal or dual seal devices with an alarm in accordance with ANSI/ISA 12.27.01. This means that the user does need to install for an external secondary process seal in the thermowell which is required in ANSI/NFPA 70 (NEC) and CSA 22.1 (CEC). These devices comply with installation practice in North America and enable very safe, low-cost installation in pressurized applications with hazardous media.
Further information is provided in the Safety Instructions (XA) for the specific device → 58 ff.

Product	Type	Max. process pressure	Marking	Listing
Liquiphant M	FTL50-S/T##... FTL50-P/Q/R##...	64 bar (928 psi)	Single Seal	CSA/FM
	FTL51-S/T##... FTL51-P/Q/R##...	64/100 bar (928/1450 psi)	Single Seal	CSA/FM
	FTL50H-S/T##... FTL50H-P/Q/R##...	64 bar (928 psi)	Single Seal	CSA/FM
	FTL51H-S/T##... FTL51H-P/Q/R##...	64 bar (928 psi)	Single Seal	CSA/FM

Other certificates

- Material certificate as per EN 10204/3.1 for all wetted parts NACE MR0175/MR0103, AD2000
- Leak detection system in conjunction with WHG approval
  Approval number: Z–65.40–446 (see also "Ordering information" s. Seite 43 ff.)
- TSE Certificate of Suitability
  The following applies to wetted device components:
  – They do not contain any materials derived from animals.
  – No additives or operating materials derived from animals are used in production or processing.

Note!
Wetted device components are listed in the "Mechanical construction" (→ 30 ff.) and "Ordering information" (→ 43 ff.) sections.

Manufacturer declarations

The following documents are optionally available to order with the device:

- FDA conformity
- TSE-free: Materials not derived from animals
- Regulation (EC) no. 2023/2006 (GMP)
- Regulation (EC) No. 1935/2004 materials in contact with food

The applicable European guidelines and standards can be found in the relevant EU Declarations of Conformity.

Regulation (EC) no. 10/2011: The regulation on plastic materials does not apply to the Liquiphant FTL5x, as the wetted materials are made exclusively of stainless steel.
The silicone seals supplied comply with BFR recommendation XV (commodities based on silicones from the Federal Institute for Risk Assessment - BFR), and the EPDM seals provided comply with BFR recommendation XXI (commodities based on natural and synthetic rubber).

Use in hazardous zones

Pay particular attention to the information provided in the documentation: Safety Instructions, Control Drawings etc. → 58

ASME B 31.3

Design and materials in accordance with ASME B31.3 The welding seals are through-penetration welded and comply with ASME Boiler and Pressure Vessel Code Section IX and EN ISO 15614-1.

Pressure equipment directive

The pressure equipment directive 97/23/EC does not apply to the Liquiphant FTL5x, as it does not have a pressurized housing in accordance with Article 1, Paragraph 2.1.4 of the directive.

Ordering information

Note!
Versions that are mutually exclusive are not indicated in this list.

Liquiphant M FTL50, FTL51 product structure

Design		*Basic weight*
FTL50	Compact	0.6 kg
FTL51	With extension pipe	0.6 kg

10	Approval:	
	A	Non-hazardous area
	B	ATEX II 3G Ex nC IIC T6, WHG, ATEX II 3D Ex tc IIIC T85°C, NEPSI II 3G Ex nC IIC T6
	C	ATEX II 3G Ex nA IIC T6, WHG, ATEX II 3D Ex tc IIIC T85°C, NEPSI II 3G Ex nA IIC T6
	D	Non-hazardous area, WHG
	E	ATEX II 1/2G Ex de IIC T6, WHG
	F	ATEX II 1/2GD Ex ia IIC T6, WHG/IECEx
	G	ATEX II 1/2GD Ex ia IIC T6/IECEx Zone0/1
	H	ATEX II 1G Ex ia IIC T6
	I	ATEX II 1/2G Ex de IIC T6/IECEx Zone0/1
	J	ATEX II 1G Ex ia IIC T6, WHG
	K	ATEX II 1/2G Ex d IIC T6/IECEx Zone0/1
	L	ATEX II 1/2G Ex d IIC T6, WHG
	M	NEPSI Ex ia IIC T6
	N	NEPSI Ex d IIC T6
	P	FM IS Cl.I,II,III Div.1 Gr.A-G, Zone 0,1,2,20,21,22
	Q	FM XP Cl.I,II,III Div.1 Gr.B-G, Gr.A-G if E5 housing selected, Zone 1,2
	R	FM NI Cl.I Div.2 Gr.A-D, Zone 0,1,2,20,21,22
	S	CSA C/US IS Cl I,II,III Div.1 Gr.A-G, Zone 0,1,2
	T	CSA C/US XP Cl I,II,III Div.1 Gr.A-G, Zone 1,2
	U	CSA C/US General Purpose
	V	TIIS Ex ia IIC T3
	W	TIIS Ex d IIB T3
	7	TIIS Ex d IIC T3
	8	TIIS Ex d IIC T6
	1	INMETRO Ex ia IIC T6 Ga/Gb
	2	INMETRO Ex d IIC T6 Ga/Gb
	3	INMETRO Ex de IIC T6 Ga/Gb
	Y	Special version, TSP-No. to be spec.

20		Process connection:			*Additional weight*
		Note! For 100 bar (1450 psi) process pressure, select the appropriate option under "Additional option"			
	GQ2	G ¾	316L	Thread ISO 228	
		Installation > accessories: weld-in adapter			
	GQ6	G ¾	AlloyC22	Thread ISO 228	
	GR2	G 1	316L	Thread ISO 228	0.2 kg
	GR6	G 1	AlloyC22	Thread ISO 228	0.2 kg
	GW2*	G 1	316L	Thread ISO 228	0.2 kg
		Installation > accessories: weld-in adapter			
	GM2*	NPT ¾	316L	Thread ASME	
	GM6	NPT ¾	AlloyC22	Thread ASME	
	GN2*	NPT1	316L	Thread ASME	0.2 kg
	GN6	NPT1	AlloyC22	Thread ASME	0.2 kg
	GE2	R ¾	316L	Thread EN10226	
	GE6	R ¾	AlloyC22	Thread EN10226	
	GF2	R 1	316L	Thread EN10226	0.2 kg

20	Process connection:							*Additional weight*
	GF6	R 1			AlloyC22		Thread EN10226	0.2 kg
	BA2	DN32	PN6 A		316L		Flange EN 1092-1 (DIN 2527 B)	1.2 kg
	BB2	DN32	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	2.0 kg
	BC2	DN40	PN6 A		316L		Flange EN 1092-1 (DIN 2527 B)	1.4 kg
	BD2	DN40	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	2.4 kg
	BE2	DN50	PN6 A		316L		Flange EN 1092-1 (DIN 2527 B)	1.6 kg
	BG2	DN50	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	3.2 kg
	BH2	DN65	PN6 A		316L		Flange EN 1092-1 (DIN 2527 B)	2.4 kg
	BJ2	DN50	PN100 A		316L	(FTL51)	Flange EN 1092-1 (DIN 2527 B)	
	BK2	DN65	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	4.3 kg
	BM2	DN80	PN10/16 A		316L		Flange EN 1092-1 (DIN 2527 B)	4.8 kg
	BN2	DN80	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	5.9 kg
	BQ2	DN100	PN10/16 A		316L		Flange EN 1092-1 (DIN 2527 B)	5.6 kg
	BR2	DN100	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	7.5 kg
	B12	DN80	PN100 A		316L	(FTL51)	Flange EN 1092-1 (DIN 2527 B)	
	B82	DN25	PN25/40 A		316L		Flange EN 1092-1 (DIN 2527 B)	1.4 kg
	CA2	DN32	PN6 B1		316L		Flange EN 1092-1 (DIN 2527 C)	1.1 kg
	CA6	DN32	PN6 B1		AlloyC22 >316L		Flange EN 1092-1 (DIN 2527)	1.1 kg
	CE2	DN50	PN6 B1		316L		Flange EN 1092-1 (DIN 2527 C)	1.5 kg
	CE6	DN50	PN6 B1		AlloyC22 >316L		Flange EN 1092-1 (DIN 2527)	1.5 kg
	CG2	DN50	PN25/40 B1		316L		Flange EN 1092-1 (DIN 2527 C)	2.9 kg
	CG6	DN50	PN25/40 B1		AlloyC22 >316L		Flange EN 1092-1 (DIN 2527)	2.9 kg
	CJ2	DN50	PN100 B2		316L	(FTL51)	Flange EN 1092-1 (DIN 2527)	
	CN2	DN80	PN25/40 B1		316L		Flange EN 1092-1 (DIN 2527 C)	5.2 kg
	CN6	DN80	PN25/40 B1		AlloyC22 >316L		Flange EN 1092-1 (DIN 2527)	5.2 kg
	CQ2	DN100	PN10/16 B1		316L		Flange EN 1092-1 (DIN 2527 C)	5.3 kg
	CQ6	DN100	PN10/16 B1		AlloyC22 >316L		Flange EN 1092-1 (DIN 2527)	5.3 kg
	C12	DN80	PN100 B2		316L	(FTL51)	Flange EN 1092-1 (DIN 2527)	
	C82	DN25	PN25/40 B1		316L		Flange EN 1092-1 (DIN 2527 C)	1.3 kg
	C86	DN25	PN25/40 B1		AlloyC22 >316L		Flange EN 1092-1 (DIN 2527)	1.3 kg
	DG2	DN50	PN40 B1		316L		Flange EN 1092-1 (DIN 2526 D)	
	DN2	DN80	PN40 B1		316L		Flange EN 1092-1 (DIN 2526 D)	
	D82	DN25	PN40 B1		316L		Flange EN 1092-1 (DIN 2526 D)	
	EG2	DN50	PN25/40 E		316L		Flange EN 1092-1	2.6 kg
	FG2	DN50	PN40 C		316L		Flange EN 1092-1 (DIN 2512 F)	2.6 kg
	NG2	DN50	PN40 D		316L		Flange EN 1092-1 (DIN 2512 N)	2.9 kg
	AA2*	1¼"	150 lbs	RF	316/316L		Flange ASME B16.5	1.2 kg
	AB2*	1¼"	300 lbs	RF	316/316L	(FTL51)	Flange ASME B16.5	2.0 kg
	AC2*	1½"	150 lbs	RF	316/316L		Flange ASME B16.5	1.5 kg
	AD2*	1½"	300 lbs	RF	316/316L	(FTL51)	Flange ASME B16.5	2.7 kg

20	Process connection:						Additional weight
	AE2*	2"	150 lbs	RF	316/316L	Flange ASME B16.5	2.4 kg
	AE6	2"	150 lbs	RF	AlloyC22 >316/316L	Flange ASME B16.5	2.4 kg
	AF2*	2"	300 lbs	RF	316/316L	Flange ASME B16.5	3.2 kg
	AG2*	2"	600 lbs	RF	316/316L (FTL51)	Flange ASME B16.5	4.2 kg
	AJ2*	2½"	300 lbs	RF	316/316L (FTL51)	Flange ASME B16.5	4.8 kg
	AL2*	3"	150 lbs	RF	316/316L	Flange ASME B16.5	4.9 kg
	AM2*	3"	300 lbs	RF	316/316L (FTL51)	Flange ASME B16.5	6.8 kg
	AM6	3"	300 lbs	RF	AlloyC22 >316/316L	Flange ASME B16.5	6.8 kg
	AN2*	3"	600 lbs	RF	316/316L (FTL51)	Flange ASME B16.5	
	AP2*	4"	150 lbs	RF	316/316L	Flange ASME B16.5	7.0 kg
	AQ2*	4"	300 lbs	RF	316/316L (FTL51)	Flange ASME B16.5	11.5 kg
	AQ6	4"	300 lbs	RF	AlloyC22 >316/316L	Flange ASME B16.5	11.5 kg
	AR2*	4"	600 lbs	RF	316/316L (FTL51)	Flange ASME B16.5	17.3 kg
	A82*	1"	150 lbs	RF	316/316L	Flange ASME B16.5	1.0 kg
	KA2	10 K 25 A		RF	316L	Flange JIS B2220	
	KC2	10 K 40 A		RF	316L	Flange JIS B2220	
	KE2	10 K 50 A		RF	316L	Flange JIS B2220	1.7 kg
	KE6	10 K 50 A		RF	AlloyC22 >316L	Flange JIS B2220	1.7 kg
	KL2	10 K 80 A		RF	316L	Flange JIS B2220	
	KP2	10 K 100 A		RF	316L	Flange JIS B2220	
	TC2*	DN25-38 (1 to 1½")			316L	ISO 2852 Tri-Clamp	
	TE2*	DN40-51 (2")			316L	ISO 2852 Tri-Clamp	0.1 kg
	YY9	Special version					
		* With CRN approval.					

30	Probe length; Type:				
	FTL50				
	AA	Compact;		Ra <3.2 µm/126 µin	
	IA	Compact;		Temperature spacer	0.6 kg
	QA	Compact;		Pressure-tight feedthrough	0.7 kg
	FTL51				
	BB	..... mm;	316L**	Ra <3.2 µm/126 µin	
	BE	..... mm;	Alloy**	Ra <3.2 µm/126 µin	
	CB	..... inch;	316L**	Ra <3.2 µm/126 µin	
	CE	..... inch;	Alloy**	Ra <3.2 µm/126 µin	2.3 kg/100 in
	DB	Length: type II*;	316L	Ra <3.2 µm/126 µin	0.1 kg
	DE	Length: type II*;	Alloy	Ra <3.2 µm/126 µin	0.1 kg
	JB	..... mm;	316L**	+ Temperature spacer	0.9 kg/m +0.6 kg
	JE	..... mm;	Alloy**	+ Temperature spacer	0.9 kg/m +0.6 kg
	KB	..... inch;	316L**	+ Temperature spacer	2.3 kg/100 in +0.6 kg
	KE	..... inch;	Alloy**	+ Temperature spacer	2.3 kg/100 in +0.6 kg
	LB	Length: type II*;	316L	+ Temperature spacer	0.1 kg +0.6 kg
	LE	Length: type II*;	Alloy	+ Temperature spacer	0.1 kg +0.6 kg
	RB	..... mm;	316L**	+ Pressure-tight feedthrough	0.9 kg/m +0.7 kg
	RE	..... mm;	Alloy**	+ Pressure-tight feedthrough	0.9 kg/m +0.7 kg
	SB	..... inch;	316L**	+ Pressure-tight feedthrough	2.3 kg/100 in +0.7 kg
	SE	..... inch;	Alloy**	+ Pressure-tight feedthrough	2.3 kg/100 in +0.7 kg
	TB	Length: type II*;	316L	+ Pressure-tight feedthrough	0.1 kg +0.7 kg
	TE	Length: type II*;	Alloy	+ Pressure-tight feedthrough	0.1 kg +0.7 kg
	YY	Special version			
		*) Replacing devices: when vertically mounting a Liquiphant **M** FTL51 with length II, the switch point is at the same height as for a Liquiphant **II** FTL360, FTL365, FDL30, FDL35. See also Seite 36 "L II" depends on process connection.			
		**) Order 3001 to 6000 mm (116 to 235 in) via yy			

40	Electronics; output:		
A	FEL50A	PROFIBUS PA	
D	FEL50D	Density/concentration without WHG approval (Germany)	
1	FEL51*	2-wire,	AC 19 to 253 V
2	FEL52*	3-wire PNP,	DC 10 to 55 V
4	FEL54	Relay DPDT,	AC 19 to 253 V, DC 19 to 55 V
5	FEL55	8/16 mA,	DC 11 to 36 V
6	FEL56	NAMUR (L-H signal)	
7	FEL57	2-wire PFM	
8	FEL58*	NAMUR + test keys (H-L signal)	
9	Special version		
	*) Also available in compact housing		

50	Housing; cable entry:				
C3	Compact 316L	IP66/68;	Cable 5 m		
D3	Compact 316L	IP65;	Plug Pg11	ISO4400	
E1	F27 316L	NEMA 4X/6P;	Thread NPT ¾		
E3	Compact 316L Hygiene	NEMA4X;	Plug NPT ½	ISO4400	
N3	Compact 316L Hygiene	IP66/68;	M12 connector		
E4	F16 Polyester	NEMA4X;	Thread NPT ½		
E5	F13 Alu F17 Alu	NEMA4X/6P; NEMA4X	Thread NPT ¾		0.5 kg
E6	F15 316L hygiene	NEMA4X;	Thread NPT ½		0.1 kg
E7	T13 Alu	NEMA4X/6P;	Thread NPT ¾		0.9 kg
	Separate connection compartment				
F1	F27 316L	IP66/68	Thread G1/2		
F4	F16 Polyester	IP66/67;	Thread G ½		
F5	F13 Alu F17 Alu	IP66/68; IP66/67;	Thread G ½		0.5 kg
F6	F15 316L Hygiene	IP66/67;	Thread G ½		0.1 kg
F7	T13 Alu	coated IP66/68; thread G ½			0.9 kg
	Separate connection compartment				
G1	F27 316L	IP66/68;	M20 threaded joint		
	Ex d > M20 thread				
G4	F16 Polyester	IP66/67;	M20 threaded joint		
G5	F13 Alu F17 Alu	IP66/68; IP66/67;	M20 threaded joint		0.5 kg
			Ex d > thread M20		
G6	F15 316L Hygiene	IP66/67;	M20 threaded joint		0.1 kg
G7	T13 Alu	coated IP66/68;	M20 threaded joint		0.9 kg
	Separate connection compartment		Ex d > thread M20		
N4	F16 Polyester	IP66/67;	M12 connector		
N5	F13 Alu F17 Alu	IP66/68; IP66/67;	M12 connector		
N6	F15 316L hygiene	IP66/67;	M12 connector		
Y9	Special version				

60	Additional option		
A	Basic version		
B	PWIS-free, PWIS = paint-wetting impairment substances, max 2000 mm (78.7 in)		
C	EN 10204 - 3.1 material (316L wetted) inspection certificate		
D	EN10204-3.1 AD2000 material, wetted, apart from cast parts, inspection certificate		
K	Special adjustment, density H20		
L	Special adjustment, density H20, EN10204-3.1, material (wetted), inspection certificate		
N	EN 10204 - 3.1 material, NACE MR0175 (316L wetted) Inspection certificate		
P	100 bar (1450 psi) process pressure	(FTL51)	
R	100 bar (1450 psi) process pressure, EN 10204 - 3.1 material, NACE MR0175 (316L wetted) Inspection certificate	(FTL51)	
S	GL/ABS marine approval for FTL51: ≤ 1600 mm (63 in)		
Y	Special version		

580		Test, certificate:
	KD	Helium leak test, internal procedure, inspection certificate
	KE	Pressure test, internal procedure, inspection certificate
	KG	PMI test (XRF), internal procedure, wetted metal parts, EN10204-3.1 inspection certificate
	KP	Dye penetration test AD2000-HP5-3(PT), wetted/pressurized metal parts, inspection certificate
	KQ	Dye penetration test ISO23277-1 (PT), wetted/pressurized metal parts, inspection certificate
	KR	Dye penetration test ASME VIII-1 (PT), wetted/pressurized metal parts, inspection certificate
	KS	Welding documentation, wetted/pressurized seams
	KV	Declaration of Conformity ASME B31.3
	K9	Special version, TSP-No. to be spec.

FTL5x -	Complete product designation

Note!
The basic weight includes the compact sensor, thread adapter G ¾, electronic insert, polyester housing

Liquiphant M FTL50H, FTL51H product structure

Design		*Basic weight*
FTL50H	Compact	0.7 kg
FTL51H	With extension pipe	0.7 kg

10	Approval:
	A Non-hazardous area
	B ATEX II 3G Ex nC IIC T6, WHG, ATEX II 3D Ex tc IIIC T85°C, NEPSI II 3G Ex nC IIC T6
	C ATEX II 3G Ex nA IIC T6, WHG, ATEX II 3D Ex tc IIIC T85°C, NEPSI II 3G Ex nA IIC T6
	D Non-hazardous area, WHG
	E ATEX II 1/2G Ex de IIC T6, WHG
	F ATEX II 1/2GD Ex ia IIC T6, WHG/IECEx
	G ATEX II 1/2GD Ex ia IIC T6/IECEx Zone0/1
	H ATEX II 1G Ex ia IIC T6
	I ATEX II 1/2G Ex de IIC T6/IECEx Zone0/1
	J ATEX II 1G Ex ia IIC T6, WHG
	K ATEX II 1/2G Ex d IIC T6/IECEx Zone0/1
	L ATEX II 1/2G Ex d IIC T6, WHG
	M NEPSI Ex ia IIC T6
	N NEPSI Ex d IIC T6
	P FM IS Cl.I,II,III Div.1 Gr.A-G, Zone 0,1,2,20,21,22
	Q FM XP Cl.I,II,III Div.1 Gr.B-G, Gr.A-G if E5 housing selected, Zone 1,2
	R FM NI Cl.I Div.2 Gr.A-D, Zone 0,1,2,20,21,22
	S CSA C/US IS Cl I,II,III Div.1 Gr.A-G, Zone 0,1,2
	T CSA C/US XP Cl I,II,III Div.1 Gr.A-G, Zone 1,2
	U CSA C/US General Purpose
	V TIIS Ex ia IIC T3
	W TIIS Ex d IIB T3
	7 TIIS Ex d IIC T3
	8 TIIS Ex d IIC T6
	1 INMETRO Ex ia IIC T6 Ga/Gb
	2 INMETRO Ex d IIC T6 Ga/Gb
	3 INMETRO Ex de IIC T6 Ga/Gb
	Y Special version, TSP-No. to be spec.

20		Process connection:					*Additional weight*
	GQ2	G ¾		316L	(FTL50H)	Thread ISO 228	
		Installation > accessories: weld-in adapter					
	GW2*	G 1		316L		Thread ISO 228	0.2 kg
		Installation > accessories: weld-in adapter					
	BA2	DN32	PN6 A	316L		Flange EN 1092-1 (DIN 2527 B)	1.2 kg
	BB2	DN32	PN25/40 A	316L		Flange EN 1092-1 (DIN 2527 B)	2.0 kg
	BC2	DN40	PN6 A	316L		Flange EN 1092-1 (DIN 2527 B)	1.4 kg
	BD2	DN40	PN25/40 A	316L		Flange EN 1092-1 (DIN 2527 B)	2.4 kg
	BE2	DN50	PN6 A	316L		Flange EN 1092-1 (DIN 2527 B)	1.6 kg

20		Process connection:						*Additional weight*
		BG2	DN50	PN25/40 A		316L	Flange EN 1092-1 (DIN 2527 B)	3.2 kg
		BH2	DN65	PN6 A		316L	Flange EN 1092-1 (DIN 2527 B)	2.4 kg
		BK2	DN65	PN25/40 A		316L	Flange EN 1092-1 (DIN 2527 B)	4.3 kg
		BM2	DN80	PN10/16 A		316L	Flange EN 1092-1 (DIN 2527 B)	4.8 kg
		BN2	DN80	PN25/40 A		316L	Flange EN 1092-1 (DIN 2527 B)	5.9 kg
		BQ2	DN100	PN10/16 A		316L	Flange EN 1092-1 (DIN 2527 B)	5.6 kg
		BR2	DN100	PN25/40 A		316L	Flange EN 1092-1 (DIN 2527 B)	7.5 kg
		B82	DN25	PN25/40 A		316L	Flange EN 1092-1 (DIN 2527 B)	1.4 kg
		CG2	DN50	PN25/40 B1		316L	Flange EN 1092-1 (DIN 2527 C)	3.2 kg
		CN2	DN80	PN25/40 B1		316L	Flange EN 1092-1 (DIN 2527 C)	5.9 kg
		CQ2	DN100	PN10/16 B1		316L	Flange EN 1092-1 (DIN 2527 C)	5.6 kg
		EE2	1" flush-mounted (52001047)			316L		0.3 kg
			Installation > accessories: weld-in adapter					
		HE2	DN50	Pipe DIN 11850 slotted nut		316L	DIN 11864-1 A	0.3 kg
		AA2*	1¼"	150 lbs	RF	316/316L	Flange ASME B16.5	1.2 kg
		AC2*	1½"	150 lbs	RF	316/316L	Flange ASME B16.5	1.5 kg
		AE2*	2"	150 lbs	RF	316/316L	Flange ASME B16.5	2.4 kg
		AF2*	2"	300 lbs	RF	316/316L	Flange ASME B16.5	3.2 kg
		AJ2*	2½"	300 lbs	RF	316/316L (FTL51H)	Flange ASME B16.5	4.8 kg
		AL2*	3"	150 lbs	RF	316/316L	Flange ASME B16.5	4.9 kg
		AM2	3"	300 lbs	RF	316/316L (FTL51H)	Flange ASME B16.5	6.8 kg
		AP2*	4"	150 lbs	RF	316/316L	Flange ASME B16.5	7.0 kg
		AQ2*	4"	300 lbs	RF	316/316L (FTL51H)	Flange ASME B16.5	11.5 kg
		A82*	1"	150 lbs	RF	316/316L	Flange ASME B16.5	1.0 kg
		KA2	10 K 25		RF	316L	Flange JIS B2220	
		KC2	10 K 40		RF	316L	Flange JIS B2220	
		KE2	10 K 50		RF	316L	Flange JIS B2220	1.7 kg
		KL2	10 K 80		RF	316L	Flange JIS B2220	
		KP2	10 K 100		RF	316L	Flange JIS B2220	
		MA2	DN32	PN25		316L	DIN 11851	0.1 kg
		MC2	DN40	PN25		316L	DIN 11851	0.2 kg
		ME2	DN50	PN25		316L	DIN 11851	0.3 kg
		PE2	DRD	65 mm		316L		0.3 kg
		TC2*	DN25-38 (1 to 1½")			316L	ISO 2852 Tri-Clamp	
		TE2*	DN40-51 (2")			316L	ISO 2852 Tri-Clamp	0.1 kg
		TT2	Ingold fitting 25x46mm			316L		
		UE2	SMS 2"	PN25		316L		0.2 kg
		WE2*	DN65-162 PN10			316L	Varivent N pipe	0.5 kg
		YY9	Special version					
			* CRN approval					

30			Probe length; Type:			
			FTL50H			
		AC	Compact;	Ra <1.5 µm/59 µin		
		AD	Compact;	Ra <0.3 µm/12 µin		
		AF	Compact;	Ra<0.76 µm/30 µin		
		IC	Compact;	Ra <1.5 µm/59 µin + temperature spacer		0.6 kg
		ID	Compact;	Ra <0.3 µm/12 µin / A3 + temperature spacer		0.6 kg
		QC	Compact;	Ra <1.5 µm/59 µin + pressure-tight feedthrough		0.7 kg
		QD	Compact;	Ra <0.3 µm/12 µin / A3 + pressure-tight feedthrough		0.7 kg
			FTL51H			
		BC	..... mm;	Ra <1.5 µm/59 µin		0.9 kg/m
		BD	..... mm;	Ra <0.3 µm/12 µin / A3		0.9 kg/m
		BF	.....mm;	Ra<0.76 µm/30 µin		0.9 kg/m
		CC	..... inch;	Ra <1.5 µm/59 µin		2.3 kg/100 in
		CD	..... inch;	Ra <0.3 µm/12 µin / A3		2.3 kg/100 in
		cf	.....inch;	Ra<0.76 µm/30 µin		2.3 kg/100 in

30	Probe length; Type:			
	DC	Length: type II*;	Ra <1.5 µm/59 µin	0.1 kg
	DD	Length: type II*;	Ra <0.3 µm/12 µin / A3	0.1 kg
	JC	..... mm;	Ra <1.5 µm/59 µin + Temperature spacer	0.9 kg/m +0.6 kg
	JD	..... mm;	Ra <0.3 µm/12 µin + Temperature spacer	0.9 kg/m +0.6 kg
	KC	..... inch;	Ra <1.5 µm/59 µin + Temperature spacer	2.3 kg/100 in +0.6 kg
	KD	..... inch;	Ra <0.3 µm/12 µin + Temperature spacer	2.3 kg/100 in +0.6 kg
	LC	Length: type II*;	Ra <1.5 µm/59 µin + Temperature spacer	0.1 kg +0.6 kg
	LD	Length: type II*;	Ra <0.3 µm/12 µin + Temperature spacer,	0.1 kg +0.6 kg
	RC	..... mm;	Ra <1.5 µm/59 µin + Pressure-tight feedthrough	0.9 kg/m +0.7 kg
	RD	..... mm;	Ra <0.3 µm/12 µin + Pressure-tight feedthrough	0.9 kg/m +0.7 kg
	SC	..... inch;	Ra <1.5 µm/59 µin + Pressure-tight feedthrough	2.3 kg/100 in +0.7 kg
	SD	..... inch;	Ra <0.3 µm/12 µin + Pressure-tight feedthrough	2.3 kg/100 in +0.7 kg
	TC	Length: type II*;	Ra <1.5 µm/59 µin + Pressure-tight feed through,	0.1 kg +0.7 kg
	TD	Length: type II*;	Ra <0.3 µm/12 µin + Pressure-tight feed through,	0.1 kg +0.7 kg
	YY	Special version		

*) Replacing devices: when vertically mounting a Liquiphant **M** FTL51H with length II, the switch point is at the same height as for a Liquiphant **II** FTL360, FTL365, FDL30, FDL35.
See also Seite 36 "L II" depends on process connection.

40	Electronics; output:		
	A	FEL50A	PROFIBUS PA
	D	FEL50D	Density/concentration without WHG approval (Germany)
	1	FEL51*	2-wire, AC 19 to 253 V
	2	FEL52*	3-wire PNP, DC 10 to 55 V
	4	FEL54	Relay DPDT, AC 19 to 253 V, DC 19 to 55 V
	5	FEL55	8/16 mA, DC 11 to 36 V
	6	FEL56	NAMUR (L-H signal)
	7	FEL57	2-wire PFM
	8	FEL58*	NAMUR + test keys (H-L signal)
	9	Special version	

*) Also available in compact housing

50	Housing; cable entry:					
	C3	Compact 316L	IP66/68;	Cable 5 m		
	D3	Compact 316L	IP65;	Plug Pg11	ISO4400	
	E3	Compact 316L Hygiene	NEMA4X;	Plug NPT ½	ISO4400	
	N3	Compact 316L Hygiene	IP66/68;	M12 connector		
	E4	F16 Polyester	NEMA4X;	Thread NPT ½		
	E5	F13 Alu F17 Alu	NEMA4X/6P; NEMA4X	Thread NPT ¾		0.5 kg
	E6	F15 316L Hygiene	NEMA4X;	Thread NPT ½		0.1 kg
	E7	T13 Alu	NEMA4X/6P;	Thread NPT ¾		0.9 kg
		Separate connection compartment				
	F4	F16 Polyester	IP66/67;	Thread G ½		
	F5	F13 Alu F17 Alu	IP66/68; IP66/67;	Thread G ½		0.5 kg
	F6	F15 316L hygiene	IP66/67;	Thread G ½		0.1 kg
	F7	T13 Alu	coated IP66/68; thread G ½			0.9 kg
		Separate connection compartment Ex d > M20 thread				
	G4	F16 Polyester	IP66/67;	M20 threaded joint		
	G5	F13 Alu F17 Alu	IP66/68; IP66/67;	M20 threaded joint Ex d > thread M20		0.5 kg
	G6	F15 316L Hygiene	IP66/67;	M20 threaded joint		0.1 kg
	G7	T13 Alu	coated IP66/68;	M20 threaded joint		0.9 kg

50						**Housing; cable entry:**		
						Separate connection compartment		Ex d > thread M20
					N4	F16 Polyester	IP66/67;	M12 connector
					N5	F13 Alu F17 Alu	IP66/68; IP66/67;	M12 connector
					N6	F15 316L hygiene	IP66/67;	M12 connector
					Y9	Special version		

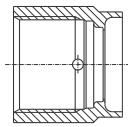
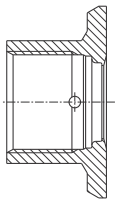
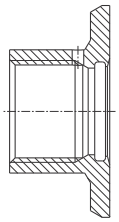
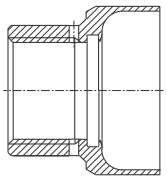
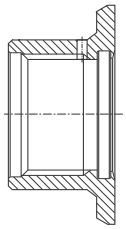
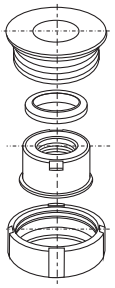
60							**Additional option**	
						A	Basic version	
						B	CoC-ASME BPE, EN10204-3.1 material (316L wetted) Inspection certificate	
						C	EN 10204 - 3.1 material (316L wetted), Inspection certificate	
						D	EN10204-3.1 AD2000 material, wetted, apart from cast parts, inspection certificate	
						K	Special adjustment, density H2O	
						L	Special adjustment, density H2O, EN10204-3.1 (316L wetted) inspection certificate	
						S	GL/ABS marine approval for FTL51H: ≤ 1600 mm (63 in)	
						Y	Special version	
FTL5#H -							Complete product designation	

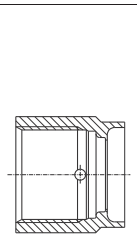
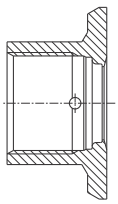
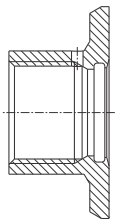
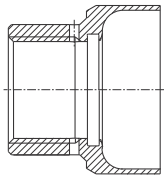
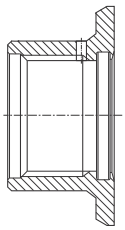
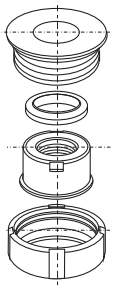
Note!
Basic weight = compact sensor, thread adapter G ¾, electronic insert, stainless steel housing

Accessories

Note!
- All dimensions in mm (in)!
- For additional information on weld-in adapters, refer to TI00426F.
- The tolerance of the thread start between the weld-in adapter and sensor is ± 15°.

Weld-in adapter **Overview**

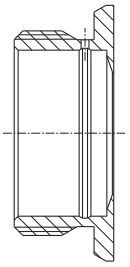
	 a0008246	 a0008251	 a0008256	 a0011924	 a0008248	 a0008253
	G¾, d=29 (1.14) without flange	**G¾, d=50 (1.97) with flange**	**G¾, d=55 (2.17) with flange**	**G1, d=53 (2.09) without flange**	**G1, d=60 (2.36) with flange**	**G1 can be positioned**
Material roughness µm (µin)	316L 1.5 (59.1)	316L 0.8 (31.5)	316L 0.8 (31.5)	316L 0.8 (31.5)	316L 0.8 (31.5)	316L 0.8 (31.5)
Without inspection certificate EN10204-3.1 material	71258357	71258355	52001052[3)]	71258358	52001051[1), 3)]	52001221[2), 3)]
With inspection certificate EN10204-3.1 material	52028295[3)]	52018765[3)]	52011897[3)]	71093129[1), 3)]	52011896[1), 3)]	52011898[2), 3)]
Seal (replacement part: set of 5)	Silicone O-ring 52021717	Silicone O-ring 52021717	Silicone O-ring 52014473	Silicone O-ring 52014472	Silicone O-ring 52014472	Silicone profile gasket 52014424)
Weld-in dummy	–	–	71168889	71166879	71166879	71181945

		 a0008246	 a0008251	 a0008256	 a0011924	 a0008248	 a0008253
		G¾, d=29 (1.14) without flange	**G¾, d=50 (1.97) with flange**	**G¾, d=55 (2.17) with flange**	**G1, d=53 (2.09) without flange**	**G1, d=60 (2.36) with flange**	**G1 can be positioned**
Liquiphant M	Feature	**Version**					
FTL50	020			GQ2			
FTL5x					GW2	GW2	GW2
FTL50H				GQ2			
FTL5xH					GW2	GW2	GW2

1) This weld-in adapter replaces the weld-in adapter with the order number 917969-1000.

2) This weld-in adapter replaces the weld-in adapter with the order number 215159-0000.

3) A seal is included in the delivery.

		 a0008252	 a0008254
		RD52	**DRD DN50 65 (2.56) (welding flange)**
Material roughness µm (µin), process side		316L 0.8 (31.5)	316L/304 0.8 (31.5)
Without inspection certificate EN10204-3.1 material		52001047 [1), 2)]	52002041[2)]/ 916743-0000
With inspection certificate EN10204-3.1 material		52006909 [1), 2)]	52011899[2)]/ –
Seal (replacement part: set of 5)		Silicone profile gasket 52014424	PTFE flat seal 52024228
Weld-in dummy		M40167	–
Device	Feature	**Version**	
Liquiphant M			
FTL5xH	020	EE2	PE2

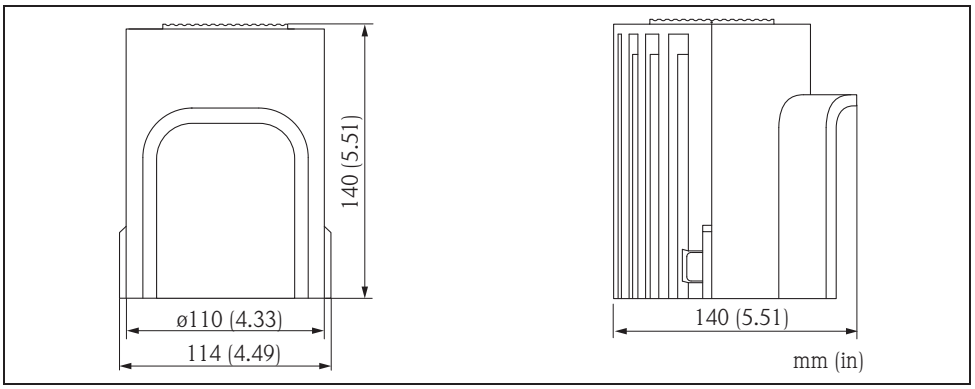
1) This weld-in adapter replaces the weld-in adapter with the order number 942329-0001.

2) A seal is included in the delivery.

Note!
All the weld-in adapters available are described in document TI00426F.
www.endress.com --> Download -->Advanced--> Documentation code --> TI00426F.

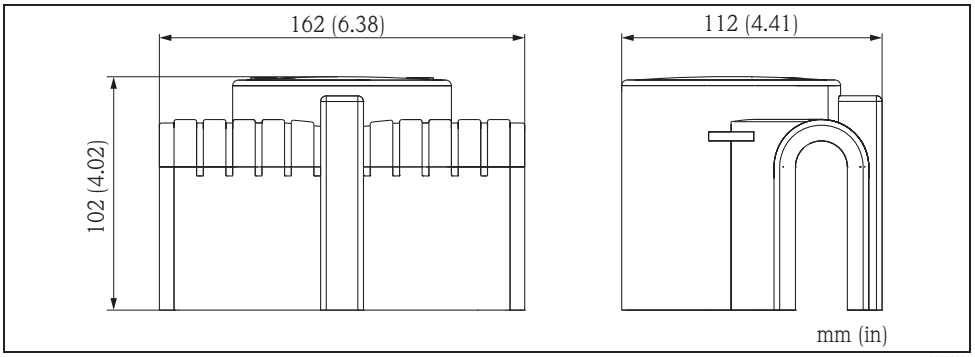
Weather protection cover

For F16 housing



Material	Order No.	Weight
PBT, gray	71127760	240 g (8.46 oz)

For F13, F17 and F27 housing



Material	Order No.	Weight
PA6, gray	71040497	300 g (10.58 oz)

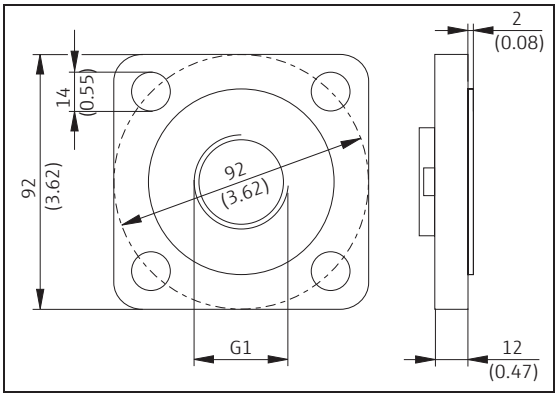
Lap joint flange

Order number: 918158-0000
With G 1 thread for mounting
a Liquiphant FTL50, FTL51
with process connection GR2

Pressure up to 40 bar (580 psi)

Material: corrosion-resistant steel
1.4301 (AISI 304)

Weight: 0.54 kg (1.19 lbs)

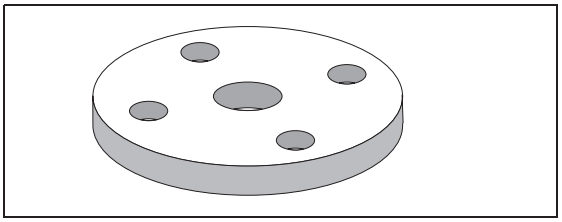


Lap joint flanges

With G 1 thread for mounting
a Liquiphant FTL50, FTL51
with process connection GR2

Material: corrosion-resistant steel
1.4571 (AISI 316Ti)

- Order number: 918143-0000
  Flange DN50 PN40, EN 1092-1
  Weight: 3.11 kg (6.86 lbs)
- Order number: 918144-0000
  Flange ASME 2", 150 psi, RF
  Weight: 2.38 kg (5.25 lbs)



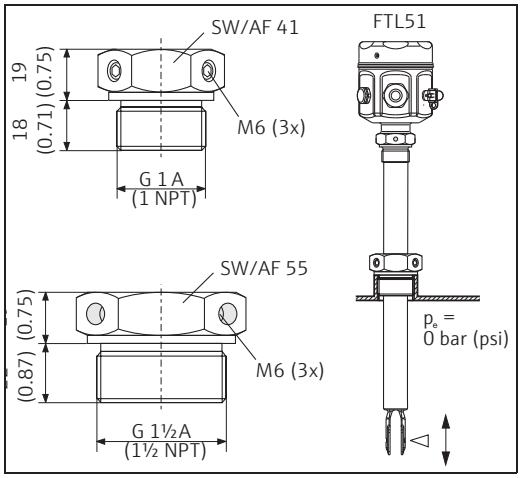
L00-FTL5xxxx-03-05-xx-xx-015

Sliding sleeves for unpressurized operation

Switch point infinitely variable for
Liquiphant M FTL51

Material: corrosion-resistant steel
1.4435 (AISI 316 L)

Weight for G 1, NPT 1: 0.21 kg (0.46 lbs)
Weight for G 1½, NPT 1½: 0.54 kg (1.19 lbs)



L00-FTL5xxxx-06-05-xx-xx-109

Thread	Standard	Material	Order number	Approval
G 1	DIN ISO 228/I	1.4435 (AISI 316 L)	52003978	
G 1	DIN ISO 228/I	1.4435 (AISI 316 L)	52011888	With inspection certificate EN 10204 - 3.1 material
NPT1	ASME B 1.20.1	1.4435 (AISI 316 L)	52003979	
NPT1	ASME B 1.20.1	1.4435 (AISI 316 L)	52011889	With inspection certificate EN 10204 - 3.1 material
G 1½	DIN ISO 228/I	1.4435 (AISI 316 L)	52003980	
G 1½	DIN ISO 228/I	1.4435 (AISI 316 L)	52011890	With inspection certificate EN 10204 - 3.1 material
NPT1½	ASME B 1.20.1	1.4435 (AISI 316 L)	52003981	
NPT1½	ASME B 1.20.1	1.4435 (AISI 316 L)	52011891	With inspection certificate EN 10204 - 3.1 material

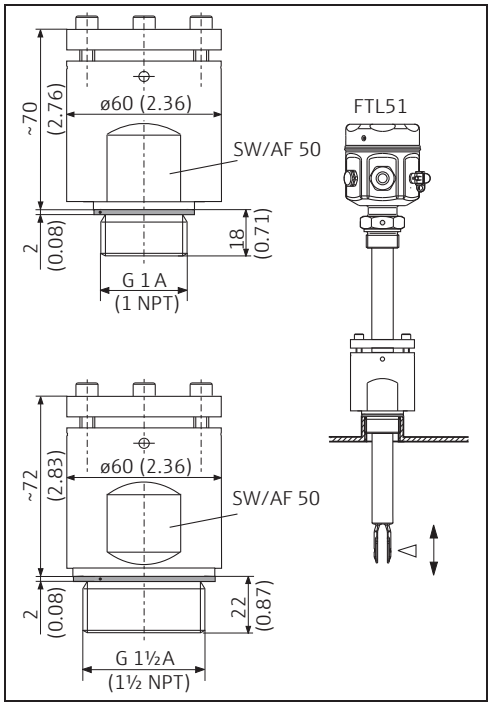
High pressure sliding sleeves

For continuous adjustment of the switch point of a Liquiphant M FTL51.
Also for use in hazardous areas. For further information → 📄 58ff. (ATEX, NEPSI).

Material: corrosion-resistant steel 1.4435 (AISI 316L) or AlloyC22

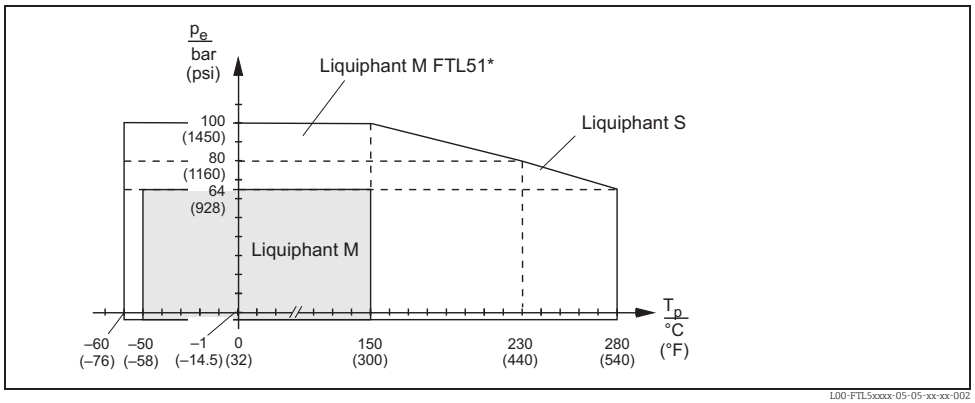
Weight for G 1, NPT 1: 1.13 kg (2.49 lbs)
Weight for G 1½, NPT 1½: 1.32 kg (2.91 lbs)

Seal package made of graphite



L00-FTL5xxxx-06-05-xx-xx-110

Thread	Standard	Material	Order number	Approval
G 1	DIN ISO 228/1	1.4435 (AISI 316 L)	52003663	
G 1	DIN ISO 228/1	1.4435 (AISI 316 L)	52011880	With inspection certificate EN 10204 - 3.1 material
G 1	DIN ISO 228/1	AlloyC22	71118691	With inspection certificate EN 10204 - 3.1 material
NPT1	ASME B 1.20.1	1.4435 (AISI 316 L)	52003667	
NPT1	ASME B 1.20.1	1.4435 (AISI 316 L)	52011881	With inspection certificate EN 10204 - 3.1 material
NPT1	ASME B 1.20.1	AlloyC22	71118694	With inspection certificate EN 10204 - 3.1 material
G 1½	DIN ISO 228/1	1.4435 (AISI 316 L)	52003665	
G 1½	DIN ISO 228/1	1.4435 (AISI 316 L)	52011882	With inspection certificate EN 10204 - 3.1 material
G 1½	DIN ISO 228/1	AlloyC22	71118693	With inspection certificate EN 10204 - 3.1 material
NPT1½	ASME B 1.20.1	1.4435 (AISI 316 L)	52003669	
NPT1½	ASME B 1.20.1	1.4435 (AISI 316 L)	52011883	With inspection certificate EN 10204 - 3.1 material
NPT1½	ASME B 1.20.1	AlloyC22	71118695	With inspection certificate EN 10204 - 3.1 material



L00-FTL5xxxx-05-05-xx-xx-002

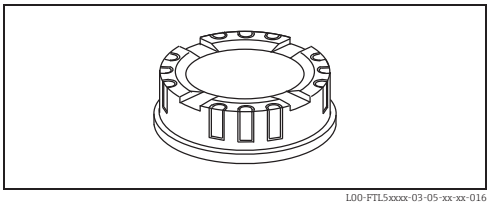
** FTL51 with high-pressure sliding sleeve (100 bar (1450 psi)). See "Additional option" Seite 43 ff. option "P" or "R".1*

Cover with sight glass

Order number: 943461-0001
for polyester housing F16

Material: PA 12

Weight: 0.04 kg (0.09 lbs)



L00-FTL5xxxx-03-05-xx-xx-016

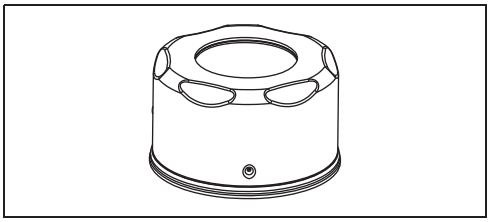
Cover with sight glass

For stainless steel housing F15

Material: AISI 316L

Weight: 0.16 kg (0.35 lbs)

- Order number: 52027002
  With glass sight glass
- Order number: 52028207
  With PC sight glass
  (Not for CSA, General Purpose)



L00-FTL5xxxx-03-05-xx-xx-017

Circular connector

Order number: 52010285

4x0.34 M12 socket

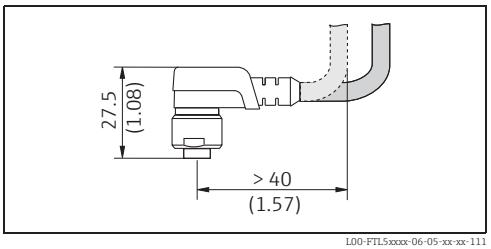
Cable: PVC (gray) 5 m (16 ft)

Body: PUR (blue)

Thread adapter nut: Cu Sn/Ni

Degree of protection: IP67

Temperature range: –25 to +70 °C (-13 to +158 °F)



L00-FTL5xxxx-06-05-xx-xx-111

Order number: 52024216

4x0.34 M12 socket

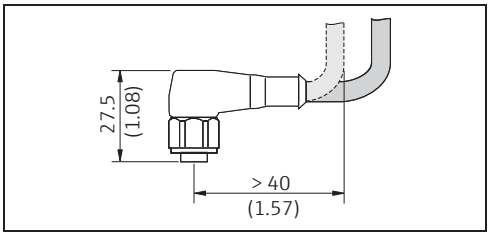
Cable: PVC (orange) 5 m (16 ft)

Body: PVC (orange)

Thread adapter nut: 316L

Degree of protection: IP69K (fully locked)

Temperature range: –25 to +70 °C (-13 to +158 °F)



L00-FTL5xxxx-06-05-xx-xx-112

Order number: 52018763

4x0.34 M12 socket with integrated LEDs

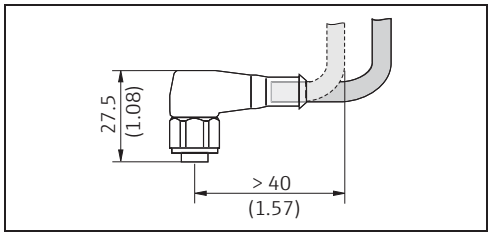
Cable: PVC (orange) 5 m (16 ft)

Body: PVC (transparent)

Thread adapter nut: 316L

Degree of protection: IP69K (fully locked)

Temperature range: –25 to +70 °C (-13 to +158 °F)



L00-FTL5xxxx-06-05-xx-xx-113

Documentation

Note!
You can find supplementary documentation on the product pages at www.endress.com

Operating Instructions

Electronic insert FEL50A for Liquiphant M, PROFIBUS PA
BA00141F

Liquiphant M Density, Density Computer FML621
BA00335F

Liquiphant M FTL50, FTL51
KA00143F

Liquiphant M FTL50(H), FTL51(H)
KA00144F

Liquiphant M FTL51C
KA00162F

Liquiphant M FTL50-####### # 7 #, FTL51-####### # 7 #
KA00163F

Liquiphant M FTL50H-######## 7 #, FTL51H-######## 7 #
KA00164F

Liquiphant M FTL51C-######## 7 ##
KA00165F

Liquiphant M FTL5#-# ### ## # #3 #, FTL5#H-# ### ## # #3 #
KA00220F

Electronic insert FEL50D for Liquiphant M Density FTL50, FTL51
KA00284F

Electronic insert FEL50D for Liquiphant M Density FTL50H, FTL51H
KA00285F

Electronic insert: FEL50D for Liquiphant M Density FTL51C
KA00286F

Liquiphant M Sliding Sleeve for FTL51, G 1, NPT 1
KA00151F

Liquiphant M Sliding Sleeve for FTL51, G 1½, NPT 1½
KA00152F

Liquiphant M High-pressure Sliding Sleeve for FTL51, G 1, NPT 1
KA00153F

Liquiphant M High-pressure Sliding Sleeve for FTL51, G 1½, NPT 1½
KA00154F

Technical Information	General instructions for electromagnetic compatibility (Test procedure, installation recommendation) TI00241F
	Liquiphant M FTL51C, wetted parts with highly corrosion-resistant ECTFE, PFA or enamel coating TI00347F
	Isolating amplifier FTL325P, 1 or 3-channel switching units for top-hat rail mounting for Liquiphant M with electronic insert FEL57 TI00350F
	Isolating amplifier FTL325N, 1 or 3-channel switching units for top-hat rail mounting for Liquiphant M with electronic insert FEL56, FEL58 TI00353F
	Liquiphant S FTL70/71, for medium temperatures up to 280 °C (536 °F) TI00354F
	Isolating amplifier FTL375P, 1 to 3-channel switching units for top-hat rail mounting for Liquiphant M with electronic insert FEL57 TI00360F
	Liquiphant M Density, Density Calculator FML621 TI00420F
	Weld-in adapter, TI00426F
Functional safety (SIL)	Liquiphant M with electronic insert FEL51 (MAX) SD00164F
	Liquiphant M with electronic insert FEL51 (MIN) SD00185F
	Liquiphant M with electronic insert FEL52 (MAX) SD00163F
	Liquiphant M with electronic insert FEL52 (MIN) SD00186F
	Liquiphant M with electronic insert FEL54 (MAX) SD00162F
	Liquiphant M with electronic insert FEL54 (MIN) SD00187F
	Liquiphant M with electronic insert FEL55 (MAX) SD00167F
	Liquiphant M with electronic insert FEL55 (MIN) SD00279F
	Liquiphant M with electronic insert FEL57 + Nivotester FTL325P (MAX) SD00111F
	Liquiphant M with electronic insert FEL57 + Nivotester FTL325P (MIN) SD00231F
	Liquiphant M with electronic insert FEL57+ Nivotester FTL375P (MAX) SD00113F
	Liquiphant M with electronic insert FEL56 + Nivotester FTL325N (MAX) SD00168F
	Liquiphant M with electronic insert FEL56 + Nivotester FTL325N (MIN) SD00188F
	Liquiphant M with electronic insert FEL58 + Nivotester FTL325N (MAX) SD00161F
	Liquiphant M with electronic insert FEL58 + Nivotester FTL325N (MIN) SD00170F

Safety Instructions (ATEX)	CE ⟨Ex⟩ II 1/2 G, Ex d IIC/B (KEMA 99 ATEX 1157) XA00031F/00/a3 CE ⟨Ex⟩ II 1/2 G, Ex ia/ib IIC/B (KEMA 99 ATEX 0523) XA00063F/00/a3 CE ⟨Ex⟩ II 1 G, Ex ia IIC/B (KEMA 99 ATEX 5172 X) XA00064F/00/a3 CE ⟨Ex⟩ II 1/2 G, Ex de IIC/B (KEMA 00 ATEX 2035) XA00108F/00/a3 CE ⟨Ex⟩ II 3 G, Ex nA/nC II (EG 01 007-a) XA00182F/00/a3
Safety Instructions (NEPSI)	Ex d IIC/IIB T3-T6 , Ex d IIC T2-T6 (NEPSI GYJ06424) XA00401F/00/B2 Ex ia IIC T2-T6, Ex ia IIB T3-T6 (NEPSI GYJ05556, NEPSI GYJ06464), XC00009F/00/b2 Ex nA II T3-T6, Ex nC/nL IIC T3-T6 (NEPSI GYJ04360, NEPSI GYJ071414) XC00010F/00/b2
Control Drawings	Liquiphant M (IS and NI) Current output PFM, NAMUR Entity installation Class I, Div. 1, 2, Groups A, B, C, D Class I, Zone 0 Class II, Div. 1, 2, Groups E, F, G Class III ZD00041F Liquiphant M, Liquiphant S (cCSAus / IS) Class I, Div. 1, Groups A, B, C, D Ex ia IIC T6 Class II, Div. 1, Groups E, F, G Class III ZD00042F Liquiphant M (NI), FTL50(H), FTL51(H), FTL51C, FTL70, FTL71 Class I, Div. 2, Groups A, B, C, D Class II, Div. 2, Groups F, G Class III ZD00043F Liquiphant M, Liquiphant S (cCSAus / XP) Class I, Groups A, B, C, D Class II, Groups E, F, G Class III ZD00240F Liquiphant M (IS and NI) PROFIBUS PA, FOUNDATION Fieldbus Class I, Zone 0, IIC Class I, Division 1, 2, Groups A, B, C, D Class II, Division 1, 2, Groups E, F, G Class III ZD00244F
System information	Liquiphant M SI00040F

www.addresses.endress.com

Endress+Hauser

People for Process Automation

4 – DETAILED TECHNICAL DOCUMENTATION

4.4 – COMMISSIONING REPORT

LEFT BLANK

DOCUMENT PROVIDED AFTER PROCESS STARTUP

LEFT BLANK

4 – DETAILED TECHNICAL DOCUMENTATION

4.5 – LIST OF SUPPLIERS

LEFT BLANK

LIST OF SUPPLIERS

SUPPLIER	ADDRESS	LOCATION	TELEPHONE
ACIER LOUBIER	2425 EDOUARD-MICHELIN	TERREBONNE	877-477-4042
ALBERT DAVIDSON INDUSTRIES LTD	4721, RUE LOUIS-B-MAYER	LAVAL	450-682-9023
ANDRITZ SEPARATION INC.	1010 COMMERCIAL BLVD. S	ARLINGTON	817-419-1706
APY ELECTRIQUE INC.	1220 RUE VERVILLE	REPENTIGNY	450-585-4000
CAMFAB	1191 RUE NOBEL	STE-JULIE	450-649-6571
CFF (QUEBEC) INC, ACIER INOXYDABLE	4900, Chemin Bois-Franc	ST-LAURENT	514-337-7700
CHEMLINE PLASTICS LTD	55 GUARDSMAN ROAD	THORNILL	905-889-7890
CONTROLES RL	894 RUE BERLIER	LAVAL	450-967-1703
CONVAL QUEBEC .	9485, TRANS CANADA HWY.	MONTREAL	1-905-828-9900
D.M. VALVE ET CONTROLES INC.	3540 BLVD. POIRIER	ST-LAURENT	514-332-4260
DOUGLAS BARWICK INC.	599 CURE BOIVIN	BOISBRIAND	450-435-3643
DRYTEC TRANS-CANADA	250 HENRY-BESSEMER	TERREBONNE	450-965-0200
ENDRESS & HAUSER CANADA - ST-LAURENT	6800, COTE DE LIESSE	ST-LAURENT	514-733-0254
ENVIREQUIP	710 COTTON MILL ROAD	CORNWALL	613-703-7930
FAFARD INC., ACIER INOXYDABLE	21 DE MONTGOLFIER	BOUCHERVILLE	450-641-4349
FIBERGRATE (SAME AS STONCOR GROUP)	95, SUNRAY STREET	WHITBY	905-430-3333
FLSMIDTH KREBS	5505 W GILLETTE RD	TUCSON	520-744-8200
GRUNDFOS CANADA INC - USD	2941 BRIGHTON ROAD	OAKVILLE	913-227-3567
HACH SALES & SERVICES CANADA	3020 GORE ROAD	LONDON	800-665-7635
HAPMAN	6002 E. KILGORE RD	KALAMAZZO	269-343-1675
JOHNSTON INDUSTRIAL PLASTICS	1916, 32E AVE	LACHINE	514-636-5055
KOFLO CORPORATION	309 CARY POINT DRIVE	CARY	847-516-3700
LUMEN INC.	117, BOUL. HYMUS	POINTE-CLAIRE	514-630-9401
MARC ARBIC INC., LES ENTREPRISES	1283 BERNIER	ST-BRUNO-DE-MONTARVILLE	450-461-1101
MCLANAHAN CORPORATION	200 WALL STREET	HOLLIDAYSBURG	814-695-9807
MCMASTER-CARR SUPPLY CO.	200, AURORA INDUSTRIAL PKWY	AURORA	330-995-5855
ONYX VALVE CO	835 INDUSTRIAL HWY	CINNAMINSON	856-829-2888
PRIMARY FLUID SYSTEMS INC.	1050 COOKE BLVD	BURLINGTON	1-800-776-6580
PULSAFEEDER, NY (EPO)	2883 BRIGHTON HENRIETTA	ROCHERTER	585-292-8000
ROGER, PRODUITS D'ACIER	1350, GRANDE-ALLÉE	TERREBONNE	450-471-2000
SCHNEIDER ELECTRIC CANADA	825 RUE BANCROFT	POINTE-CLAIRE	514-697-4790
SCHUTTE & KOERTING	2510 METROPOLITAN DRIVE	TREVOSE	215-639-0900
SEEPEX INC.	511 SPEEDWAY DRIVE	ENON	937-864-7150
SULZER PUMPS CANADA INC	1401 MEYERSIDE DRIVE	MISSISSAUGA	905-670-4677
WAM USA, INC.	75 BOULDERBROOK CIRCLE	LAWRENCEVILLE	770-339-6767
WESTBURNE	3555, RUE SARTELON	MONTREAL	514-337-5331

LEFT BLANK

5 – ELECTRICITY AND CONTROL

5.1 – FUNCTIONAL DESCRIPTION

LEFT BLANK

FUNCTIONAL DESCRIPTION

AGNICO EAGLE MINES Ltd - AMARUQ
Water Treatment Plant

5000218009_FD_0001

REV. 2

Date : 09/08/2018

Drafted by : Fabrice Vinci, Eng.
Reviewed by: Guillaume Perin, P.eng. M.Sc

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Project definition

Veolia Water Technologies Canada (VWT) was contracted by Agnico Eagle Mines (AEM) to supply the equipment for the water treatment plant for Arsenic and TSS at the Amaruq Mine in Nunavut.

VWT is responsible for the engineering and supply of the equipment and the control system detailed in Veolia Proposal #TIH128505.

This functional description shall be read in conjunction with the related documents as listed in Section 1.3.

1.2 Process summary

AEM is currently developing the Amaruq Mine in Nunavut Canada as an open pit mine. With this new mine development AEM currently has a requirement to treat for TSS and Arsenic (As) concentration which is also expected to rise up. Therefore, an As and TSS treatment system is required before discharging the surface water to the environment.

The proposed treatment system includes:

- **A new metal precipitation reactor**. The purpose of this step is to precipitate the arsenic. The influent is sent to the Arsenic Removal Reactor. In this reactor, the influent water is mixed with ferric sulfate (Fe2(SO4)3). The ferric sulfate forms a floc of ferric hydroxide (Fe(OH)3) which acts both as a bridge to tie colloidal particles together and as an active surface which forms surface complexes with many metals, such as arsenic. The ferric sulfate also lowers the pH in the vicinity of 7.0 where the surface complexation is optimal for arsenate. In summer operation (ACTIFLO mode), some sludge from the sludge splitter box that collects the sludge from the ACTIFLO's is recycled to the metal precipitation reactor. This sludge recirculation makes it possible to increase the efficiency of the reactor and thereby reduce its size and especially prevent from having to use two units during the operation in ACTIFLO mode (high flow rate).
- **Two ACTIFLO's** (reused from the Meadowbank site). The water from the Metal Precipitation Reactor flows to the existing ACTIFLO's. The ACTIFLO is designed to remove suspended solids from the raw water. Sand-ballasted settling is a high-rate coagulation/flocculation/sedimentation process that utilizes microsand as a seed for floc formation. The microsand provides a surface area that enhances flocculation and acts as a ballast or weight. The resulting floc settles very fast, allowing for compact clarifier designs with high overflow rates and short detention times. The use of microsand also permits the unit to perform well under dramatically changing flow rates without impacting final effluent quality. The water flows to the first basin, the coagulation chamber where the reaction is optimized. The coagulated water then overflows to a second tank section called the injection tank. There, the microsand and flocculant aid polymer are added. The microsand provides a large contact area for floc attachment and acts as a ballast, thereby accelerating the settling of the flocs. The flocculant aid polymer binds the destabilized suspended solids to the microsand particles by forming polymer bridges. From the injection tank, the water

underflows to a third tank section called the maturation tank. In this section, the microsand and sludge flocs agglomerate and grow into high-density flocs known as microsand ballasted flocs. From the maturation zone, the water overflows to the settling section of the tank. In the settling zone, the microsand ballasted flocs settle quickly to the bottom of the unit. In the settling zone, the efficiency of settling is further increased by the use of the lamella tubes. The clarified water exits the system via a series of collection troughs or weirs. The clarified water is monitored for turbidity and is discharged by gravity to the clarified pump station. The sand-sludge mixture settles to the bottom of the clarifier. Scrapers force the sludge collected at the bottom of the clarifier into a centre cone from which it is continuously withdrawn and pumped to hydrocyclones where the sludge and microsand are separated by centrifugal force. After separation, the higher density microsand is discharged from the bottom of the hydrocyclone and reinjected into the process for reuse. The lighter density sludge is discharged from the top of the hydrocyclone and directed to the sludge management facilities. Also, to maintain a good extraction of sludge and good sand recirculation, the recirculation pumps on both existing ACTIFLO® units have been upgraded. The two 34 m^3/h each pumps installed on each ACTIFLO® from the Meadowbank project have been replaced by two new 70 m^3/h extraction pumps. This means that the recirculation line and hydrocyclones also had to be replaced.

- **A new sludge dewatering system.** The dewatering step aims to reduce sludge volume and produce a solid cake. In summer operation, the sludge from the two Actiflo's is sent to a sludge splitter box (existing tank reused). The sludge overflow of the splitter box flows back to the Metal Precipitation Reactor. The recycled sludge increases the reagent efficiency and promotes solid growth. It also helps to optimise the contact time between ferric hydroxide and arsenic to improve adsorption (this physical process is taking about an hour). It also thickens the sludge, so no thickener equipment is required before the dewatering stage. The remaining sludge is pumped to a storage double tank which is used as a feed tank to the centrifuges. In winter operation, the sludge from the Actiflo's (used as Multiflo's) is pumped directly to the storage double tank without going through the sludge splitter box and without being recirculated to the metal precipitation reactor. Then, both for summer and winter operation, the sludge from the storage double tank tank is pumped into two centrifuges capable of producing a cake of about 20±5 % dryness. The sludge dryness is dependent on the dewatering method, TSS content in the influent, flow rate and nature of the solid particles. In addition to the solids included in raw water, the sludge will contain adsorbed arsenic as well as ferric hydroxides from the coagulant addition. The lower the hydroxide fraction, the greater the dry solid content is achieved in the cake. The final cake dryness must be defined by carrying laboratory tests. The centrifuges are fed continuously with constant solid content slurry. A cationic polymer is injected in the feed pipe to increase the cake dryness. The separation between liquid and solid is achieved using centrifugal forces 500 to 3000 times the force of gravity. The thickened sludge produced by each centrifuge is carried away to a container for disposal through a screw conveyor. Centrate from the centrifuges and from the screw conveyors flows by gravity to sump pump pits. Centrate contains cationic polymer and can be recycled back upstream of the water treatment plant, in the metal precipitation reactor.
- **A new potassium permanganate ($KMnO_4$) preparation and dosing system**. $KMnO_4$ is used to oxidize the arsenic trivalent to produce arsenic pentavalent that is much easier to precipitate and separate from water. The selected oxidant to oxide As is Hydrex 9571. It is delivered dry in bags of 25 kg. The solution

preparation is be made using a new manual make-up system. The dosage is performed using a new dosing skid equipped with mechanical diaphragm metering pumps. The $KMnO_4$ dosing point is located upstream from the precipitation reactor.

- **A coagulant dosing system.** The selected coagulant is Hydrex 6266, a ferric sulfate coagulant. It will be received in bulk bags. The existing coagulant preparation system from the Meadowbank site is reused. For summer operation, the dosage is performed using a new dosing skid equipped with mechanical diaphragm metering pumps. For winter operation, the existing dosing system with progressive cavity pumps from the Meadowbank site is reused. The coagulant dosing point is located in the metal precipitation reactor.
- **A sulphuric acid dosing system.** Sulphuric acid is used for ferric sulfate preparation (coagulant). Sulphuric acid is a commodity and will be received in bulk containers of 1 m3 at 93 % concentration. The product can be used as is and the dosage will be performed using a new dosing skid equipped with mechanical diaphragm metering pumps. The sulphuric acid dosing point is located in the maturation tank of the coagulant preparation system.
- **A caustic soda (NaOH) preparation and dosing system.** The coagulant consumes alkalinity from the water. In the event that the water doesn't contain enough alkalinity, an alkali source, such as sodium hydroxide, will need to be added. The sodium hydroxide will be received dry in 25 kg bags. The existing preparation and dosing systems from the Meadowbank site are reused. The NaOH dosing point is located upstream from the precipitation reactor.
- **An anionic polymer preparation and dosing system.** The use of a flocculation agent is essential for a metal removal process. Polymer enables the attachment of the floc onto the microsand and as such is required in order to obtain good process performance. The polymer will be Hydrex 6105 or equivalent. It is a solid anionic polymer used to enhance flocculation and will be received in 25 kg bags. The existing Hydra-Pol automatic preparation system from the Meadowbank site is reused to prepare a 0.25 % solution. The automatic polymer preparation/dilution system is an automatically controlled batching unit capable of preparing polymers. For winter operation, the anionic polymer dosing system from the Meadowbank site is reused. For summer operation, a new dosing system with 3 dosing skids is used. The existing polymer preparation from the Meadowbank site is also reused for summer operation. The anionic polymer liquid solution injection points are located in the injection and maturation tanks of the two ACTIFLO's.
- **A cationic polymer preparation and dosing system.** Cationic polymer is required for the sludge dewatering step. A new Hydra-Pol automatic preparation system is used to prepare a 0.3-0.5 % solution. The water used for the polymer preparation needs to be filtered water with temperature between 10- 20 °C. The automatic polymer preparation/dilution system is an automatically controlled batching unit capable of preparing polymers. A new dosing system with 3 dosing skids is used. The cationic polymer liquid solution injection points are located upstream from the two centrifuges.

1.3 Reference documents

- P&IDs #5000218009_PI001 SHEETS 1 TO 19
- AEM Amaruq project - ACTIFLO® functional description

- AEM Amaruq project - MULTIFLO functional description

1.4 Abbreviations

AEM: Agnico Eagle Mines
DosT: Dosing time
HMI: Human/Machine Interface
H-O-A: Hand-Off-Auto
LCP: Local Control Panel
MPR: Metal Precipitation Reactor
ORP: Oxydation Reduction Potential
PLC: Programmable Logic Controller
SP: Set Point
TSS: Total suspended solids
VFD: Variable Frequency Drive
WTP: Water Treatment Plant

1.5 Units

The following lists the parameters referred to in this document and the units they are measured in unless otherwise specified.

- Concentration (in general): mg/L
- Dimensions : m
- Dosing rate: mL/L
- Flow rate (chemical dosing): L/h
- Flow rate (main process): m^3/h
- Level in the tanks: % or m
- pH: -
- Pressure: kPa
- Density: kg/m^3
- Temperature: °C
- Total suspended solids: mg/L
- Turbidity: NTU
- Volume: m3
- Weight : kg

1.6 Control devices

Table 1.6 : control devices for the project

P&ID TAG	DESCRIPTION	CONTROLLED (Yes/No)	COMMENTS
METAL PRECIPITATION			
M1-011	MPR 1st compartment mixer	Y	
M1-012	MPR 2nd compartment mixer	Y	
M1-013	MPR 3rd compartment mixer	Y	
AIT1-013	Influent raw water turbidity meter	Y	
FIT1-011	Influent raw water flow meter	Y	
FV1-012	MPR inlet flow control valve	Y	
AIT1-014	MPR inlet pH meter	Y	
LSHH1-011	MPR very high level switch	Y	
AIT1-011	MPR ORP sensor	Y	
AIT1-012	MPR outlet pH meter	Y	
TT15-001	MPR outlet temperature sensor	Y	
ACTIFLO 1			
FIT2-011	ACTIFLO 1 inlet water flow meter	Y	
FCV2-011	ACTIFLO 1 inlet flow control valve	Y	
M2-011	ACTIFLO 1 Coagulation tank mixer	Y	
M2-012	ACTIFLO 1 Injection tank mixer	Y	
M2-013	ACTIFLO 1 Maturation tank mixer	Y	
LSHH2-011	ACTIFLO 1 very high level switch	Y	
S2-011	ACTIFLO 1 Scraper driver	Y	
WT2-011	ACTIFLO 1 Scraper driver torque transmitter	Y	
P2-011	ACTIFLO 1 Summer recirculation pump 1	Y	
P2-012	ACTIFLO 1 Summer recirculation pump 2	Y	

P2-014	MULTIFLO extraction pump	Y	
P2-013	Clarified water pump	Y	
AIT2-011	ACTIFLO 1 outlet pH meter	Y	
AIT2-012	ACTIFLO 1 outlet turbidity meter	Y	
C2-011	ACTIFLO 1 hydrocyclone 1	N	
C2-012	ACTIFLO 1 hydrocyclone 2	N	
PI2-011	ACTIFLO 1 hydrocyclone 1 inlet pressure indicator	N	
PI2-012	ACTIFLO 1 hydrocyclone 2 inlet pressure indicator	N	
ACTIFLO 2			
FIT2-021	ACTIFLO 2 inlet water flow meter	Y	
FCV2-021	ACTIFLO 2 flow control valve	Y	
M2-021	ACTIFLO 2 Coagulation tank mixer	Y	
M2-022	ACTIFLO 2 Injection tank mixer	Y	
M2-023	ACTIFLO 2 Maturation tank mixer	Y	
LSH2-021	ACTIFLO 2 very high level switch	Y	
S2-021	ACTIFLO 2 Scraper driver	Y	
WT2-021	ACTIFLO 2 Scraper driver torque transmitter	Y	
P2-021	ACTIFLO 2Summer recirculation pump 1	Y	
P2-022	ACTIFLO 2 Summer recirculation pump 2	Y	
P2-023	MULTIFLO extraction pump	Y	
AIT2-021	ACTIFLO 2 outlet pH meter	Y	
AIT2-022	ACTIFLO 2 outlet turbidity meter	Y	
C2-021	ACTIFLO 2 hydrocyclone 1	N	
C2-022	ACTIFLO 2 hydrocyclone 2	N	
PI2-021	ACTIFLO 2 hydrocyclone 1 inlet pressure indicator	N	
PI2-022	ACTIFLO 2 hydrocyclone 2 inlet pressure indicator	N	
SLUDGE DEWATERING			

T4-011	Sludge splitter box	N	
LSHH4-011	Sludge splitter box very high level switch	Y	
LSLL4-012	Sludge splitter box very low level switch	Y	
P4-011	Splitter box sludge extraction pump 1	Y	
P4-021	Splitter box sludge extraction pump 2	Y	
PI4-011	Splitter box recirculation pressure indicator	N	
AIT4-011	Splitter box recirculation turbidity meter	Y	
FIT4-011	Splitter box outlet flow meter	Y	
FCV4-011	Splitter box outlet flow control valve	Y	
T5-011/012	Storage double tank	N	
LIT5-013	Storage double tank level transmitter 1	Y	
LSL5-012	Storage double tank very low level switch 1	Y	
LSHH5-011	Storage double tank very high level switch 1	Y	
M5-011	Storage double tank mixer 1	Y	
M5-012	Storage double tank mixer 2	Y	
LIT5-023	Storage double tank level transmitter 2	Y	
LSL5-022	Storage double tank very low level switch 2	Y	
LSHH5-021	Storage double tank very high level switch 2	Y	
P5-011	Centrifuge feeding pump 1	Y	
TSE5-011	Centrifuge feeding pump 1 high temperature switch	Y	
PI5-011	Centrifuge feeding pump 1 pressure indicator	N	
PSL5-011	Centrifuge feeding pump 1 low pressure switch	Y	
FIT5-011	Centrifuge feeding pump 1 flow transmitter	Y	

P5-012	Centrifuge feeding pump 2	Y	
TSE5-012	Centrifuge feeding pump 2 high temperature switch	Y	
PI5-012	Centrifuge feeding pump 2 pressure indicator	N	
PSL5-012	Centrifuge feeding pump 2 low pressure switch	Y	
FIT5-012	Centrifuge feeding pump 2 flow transmitter	Y	
CF6-011	Centrifuge 1	Y	
CF6-021	Centrifuge 2	Y	
CV6-011	Thickened sludge conveyor 1	Y	
CV6-021	Thickened sludge conveyor 2	Y	
S6-011	Centrate sump pump pit 1	N	
P6-011	Centrate sump pump 1	Y	
LSLL6-011	Centrate sump pump pit 1 very low level switch	Y	
LSHH6-012	Centrate sump pump pit 1 very high level switch	Y	
S6-021	Centrate sump pump pit 2	N	
P6-021	Centrate sump pump 2	Y	
LSLL6-021	Centrate sump pump pit 2 very low level switch	Y	
LSHH6-022	Centrate sump pump pit 2 very high level switch	Y	
CAUSTIC SODA PREPARATION AND DOSING SYSTEM			
T9-541	Caustic soda preparation tank	N	

M9-541	Caustic soda mixer	Y	
T9-542	Caustic soda dosing tank	N	
P9-541	Caustic soda metering pump 1	Y	
TSE9-541	Caustic soda metering pump 1 high temperature switch	Y	
P9-542	Caustic soda metering pump 2	Y	
TSE9-542	Caustic soda metering pump 2 high temperature switch	Y	
P9-543	Caustic soda metering pump 3	Y	
TSE9-543	Caustic soda metering pump 3 high temperature switch	Y	
COAGULANT PREPARATION AND DOSING SYSTEM			
V9-518	Coagulant preparation water valve	Y	
FI9-511	Coagulant service water flow indicator	N	
MO9-511	Coagulant preparation trolley	N	
MO9-512	Coagulant preparation hoist	N	
B9-513	Coagulant blower	Y	
LSL9-513	Coagulant preparation low level switch	Y	
DF9-511	Coagulant dry feeder	Y	
T9-511	Coagulant maturation tank	N	
M9-511	Coagulant preparation mixer	Y	
LIT9-511	Coagulant maturation tank level transmitter	Y	

P9-515	Coagulant transfer pump	Y	
TSE9-515	Coagulant transfer pump high temperature switch	Y	
T9-512	Coagulant dosing tank	N	
LIT9-512	Coagulant dosing tank level transmitter	Y	
P9-514	Coagulant metering pump 4	Y	Summer operation
P9-516	Coagulant metering pump 5	Y	Summer operation
P9-511	Coagulant metering pump 1	Y	Winter operation
TSE9-511	Coagulant metering pump 1 high temperature switch	Y	
P9-512	Coagulant metering pump 2	Y	Winter operation
TSE9-512	Coagulant metering pump 2 high temperature switch	Y	
P9-513	Coagulant metering pump 3	Y	Winter operation
TSE9-513	Coagulant metering pump 3 high temperature switch	Y	
SULFURIC ACID DOSING SYSTEM			
T9-531	Sulfuric acid storage tank	N	
LSL9-531	Sulfuric acid storage low level switch	Y	
P9-531	Sulfuric acid metering pump 1	Y	
P9-532	Sulfuric acid metering pump 2	Y	
ANIONIC POLYMER PREPARATION AND DOSING SYSTEM			
MO9-521	Anionic polymer vacuum conveyor	N	

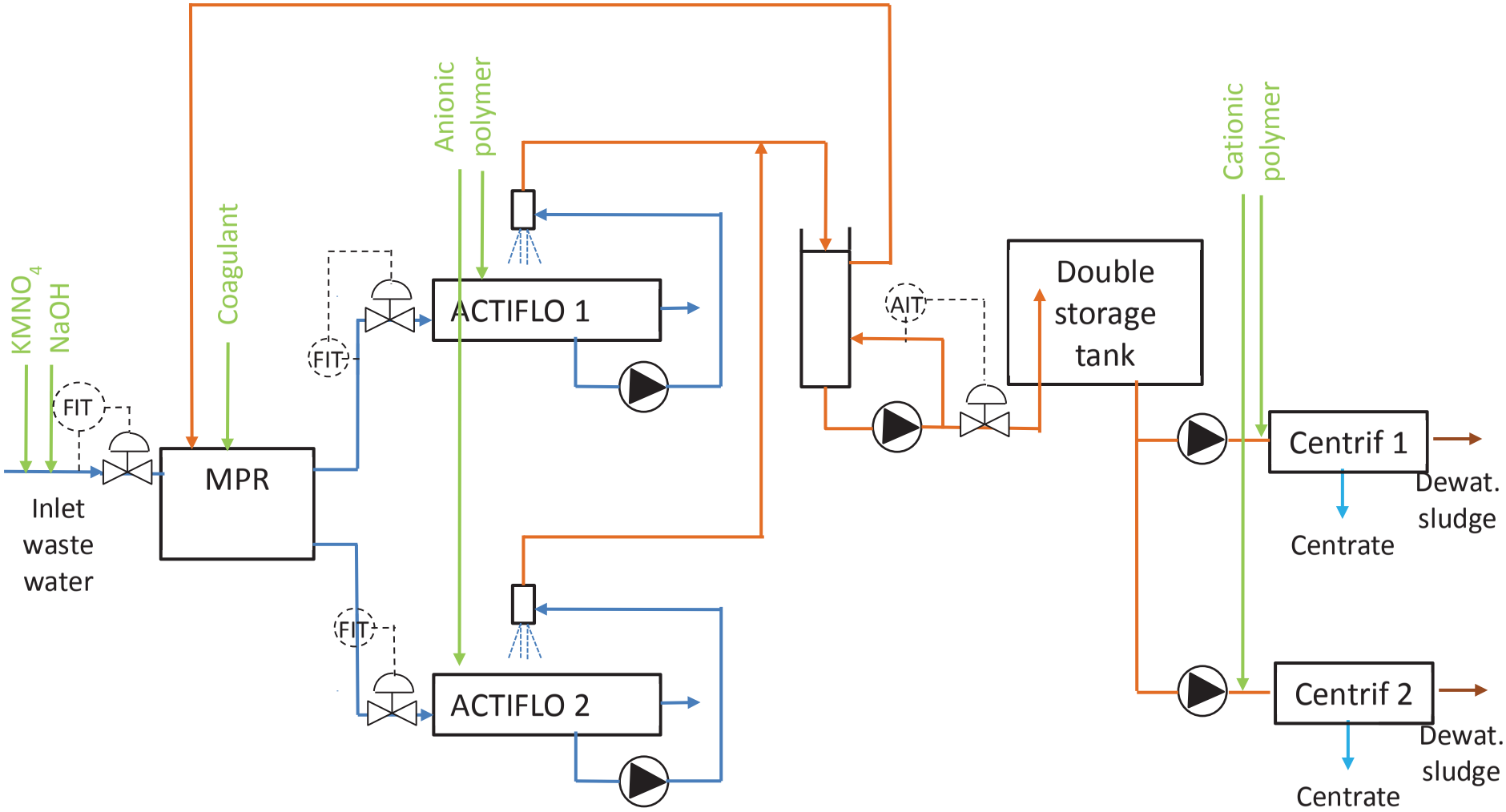
DF9-521	Anionic polymer dry feeder	Y	
PSL9-522	Anionic polymer service water low pressure switch	Y	
PSL9-521	Anionic polymer instrument air low pressure switch	Y	
BWEPMT1	Anionic polymer maturation tank	Y	
M9-521	Anionic polymer mixer	N	
PT9-521	Anionic polymer maturation tank level transmitter	Y	
BWDPMT2	Anionic polymer storage tank	Y	
PT9-522	Anionic polymer storage tank level transmitter	Y	
P9-521	Anionic polymer metering pump 1	Y	Winter operation
TSE9-521	Anionic polymer metering pump 1 high temperature switch	Y	
P9-522	Anionic polymer metering pump 2	Y	Winter operation
TSE9-522	Anionic polymer metering pump 2 high temperature switch	Y	
P9-523	Anionic polymer metering pump 3	Y	Winter operation
TSE9-523	Anionic polymer metering pump 3 high temperature switch	Y	
P9-524	Anionic polymer metering pump 4	Y	Summer operation
TSE9-524	Anionic polymer metering pump 4 high temperature switch	Y	
P9-525	Anionic polymer metering pump 5	Y	Summer operation
TSE9-525	Anionic polymer metering pump 5 high temperature switch	Y	

P9-526	Anionic polymer metering pump 6	Y	Summer operation
TSE9-526	Anionic polymer metering pump 6 high temperature switch	Y	
V9-521	Anionic polymer water transport valve 1	Y	
V9-522	Anionic polymer water transport valve 2	Y	
SV15-011	Anionic polymer water transport valve 3	Y	
SV15-021	Anionic polymer water transport valve 4	Y	
POTASSIUM PERMANGANATE PREPARATION AND DOSING SYSTEM			
VCM9-591	Potassium permanganate pneumatic conveyor	Y	
FMM9-591	Potassium permanganate feeder hopper agitator	Y	
FSM9-591	Potassium permanganate feeder screw	Y	
ZS9-591	Potassium permanganate vacuum conveyor switch	Y	
LSL9-591	Potassium permanganate low level switch	Y	
PSL15-041	Potassium permanganate service water low pressure switch	Y	
T9-591	Potassium permanganate maturation tank	N	
M9-591	Potassium permanganate mixer	N	
LT9-591	Potassium permanganate maturation tank level transmitter	Y	
T9-591-V002	Potassium permanganate transfer valve	Y	
T9-592	Potassium permanganate storage tank	N	
LT9-592	Potassium permanganate storage tank level transmitter	Y	

SV15-041	Potassium permanganate preparation 4-way solenoid valve	Y	
SV15-042	Potassium permanganate preparation service water solenoid valve	Y	
P9-591	Potassium permanganate metering pump 1	Y	
P9-592	Potassium permanganate metering pump 2	Y	
CATIONIC POLYMER PREPARATION AND DOSING SYSTEM			
HST9-621	Cationic polymer hoist	N	
TR9-621	Cationic polymer trolley	N	
LSL9-621	Cationic polymer low level switch	Y	
FMM9-621	Cationic polymer feeder hopper agitator	Y	
FSM9-621	Cationic polymer feeder screw	Y	
PSL18-031	Cationic polymer service water low pressure switch	Y	
T9-621	Cationic polymer maturation tank	N	
M9-621	Cationic polymer mixer	N	
LT9-621	Cationic polymer maturation tank level transmitter	Y	
T9-621-V002	Cationic polymer transfer valve	Y	
T9-622	Cationic polymer storage tank	N	
LT9-622	Cationic polymer storage tank level transmitter	Y	
SV18-031	Cationic polymer preparation 4-way solenoid valve	Y	
SV18-032	Cationic polymer preparation service water solenoid valve	Y	

P9-621	Cationic polymer metering pump 1	Y	
TSE9-621	Cationic polymer metering pump 1 high temperature switch	Y	
P9-622	Cationic polymer metering pump 2	Y	
TSE9-622	Cationic polymer metering pump 2 high temperature switch	Y	
P9-623	Cationic polymer metering pump 3	Y	
TSE9-623	Cationic polymer metering pump 3 high temperature switch	Y	

1.7 Overall plant control



2 FUNCTIONAL DESCRIPTION OF SYSTEMS

2.1 Metal precipitation reactor

2.1.1 Description

The purpose of this step is to precipitate the arsenic by using ferric sulfate coagulant. Coagulant is injected directly in the reactor.

Potassium permanganate ($KMnO_4$) is used to oxidize the arsenic trivalent to produce arsenic pentavalent that is much easier to precipitate and separate from water. $KMnO_4$ is injected upstream of the MPR. The operator will follow the ORP measurement in the MRP and adjust the $KMnO_4$ dosage concentration as required.

As the coagulant consumes alkalinity from the water, it may be necessary to add sodium hydroxide as an alkali source. NaOH is injected upstream of the MPR, proportionally to the raw water influent flow rate. The operator will select a NaOH dosage concentration set point based on the alkalinity of the water. A correction, based on the pH measurement in the MPR, is applied to the required NaOH injection flowrate.
The pH is measured at two locations in the MPR (inlet ant outlet compartments) by two distinct sensors.

The influent raw water flow rate is used:

- for the injection of chemicals proportionally to the raw water flow rate
- to control the opening of the MPR inlet flow control valve

2.1.2 Controls

FIC1-011 control loop will act on the opening of the MPR inlet flow control valve to adjust the influent flow rate to its set point (adjustable by the operator).

2.1.3 Fault response

The following are the faults that require control actions:

- MPR very high pH
- Failure of one of the MPR mixers
- Failure of two or three MPR mixers

MPR very high pH
An operator alarm is activated. Alarm auto-reset if pH goes back under the very high alarm set point.

Failure of one of the MPR mixers
An operator alarm is activated.

Failure of two or three MPR mixers
An operator alarm is activated and the Actiflo/Multiflo normal shutdown sequence is activated and the MPR inlet flow control valve is closed.

2.1.4 Interlocks

The MPR inlet flow control valve is interlocked with the MPR very high level. If the very high level switch is activated, control valve is closed.

2.2 ACTIFLO®

When the raw water inlet flow rate is below the capacity of one Actiflo® ACP-700R, the operator will keep only one Actiflo® in operation.
When the raw water inlet flow rate is above the capacity of one Actiflo® ACP-700R, the operator will have the two Actiflo's in operation.

Based on the inlet raw water TSS (measured by AIT1-013), the operator will choose to start one or two microsand recirculation pumps per ACTIFLO.

Refer to ACTIFLO® standard functional description for details.

2.3 MULTIFLO

Refer to MULTIFLO standard functional description.

2.4 Sludge transfer and dewatering

2.4.1 Sludge from ACTIFLO's to sludge double storage tank

2.4.1.1 Description

In summer operation, the sludge from the hydrocyclones of the Actiflo's flows by gravity to the sludge splitter box. From the sludge splitter box, the sludge is then pumped to a sludge double storage tank. The flow rate to the sludge storage tank is controlled through a control valve and a turbidity control loop. The overflow of sludge in the splitter box flows by gravity back to the MPR.
A recirculation loop on the sludge splitter box prevents sludge from settling. The sludge recirculation loop is equipped with a turbidity meter.

In winter operation, the sludge from the Actiflo's (used as Multiflo's) is pumped directly to the storage double tank without going through the sludge splitter box and without being recirculated to the metal precipitation reactor.

2.4.1.2 Control

AIC4-011 turbidity control loop will act on the opening of the splitter box outlet flow control valve to adjust the sludge flow rate being recirculated back to the MPR.
A turbidity set point will be entered by the operator. If the measured turbidity is below the set point, the control loop will close FCV4-011. This will increase the sludge recirculation to the MPR and increase the turbidity.
On the contrary, if the measured turbidity is above the set point, the control loop will open FCV4-011. This will decrease the sludge recirculation to the MPR and increase the sludge flow rate going to the sludge double storage tank.

There are two splitter box sludge extraction pumps. Based on the inlet raw water TSS (measured by AIT1-013), the operator will choose to start one or two microsand recirculation pumps for each ACTIFLO. If only one microsand recirculation pump of each ACTIFLO is in operation, the operator will start only one splitter box sludge extraction pump. If the two recirculation pumps of each ACTIFLO are in operation, the operator will start both splitter box sludge extraction pumps.

2.4.1.3 Fault response

When a splitter box sludge extraction pump fails, the other pump takes over the failing pump automatically and an alarm is activated. If the second pump fails too, a critical alarm is activated and the Actiflo's upstream are stopped on an emergency shutdown sequence and the MPR inlet flow control valve is closed.

2.4.1.4 Interlocks

The splitter box sludge extraction pumps are interlocked with the very low level of the sludge splitter box. If the very low level switch is activated, the pumps are stopped ~~and an emergency stop is triggered on the ACTIFLO's.~~

When the very high level switch of the sludge splitter box is activated, the Actiflo's upstream are stopped on an emergency shutdown sequence and the MPR inlet flow control valve is closed.

2.4.2 Sludge from sludge double storage tank to centrifuge

2.4.2.1 Description

Mixers located in the sludge double storage tank prevent sludge from settling. They are in operation as long as the liquid level in the tank is sufficient.
The sludge double storage tank has two compartments that are used in parallel. Each compartment of the tank is equipped with a level transmitter.
The sludge from the storage double tank is pumped into two centrifuges. Each centrifuge has its dedicated progressive cavity feed pump equipped with a VFD.

The sludge dewatering system is composed of two centrifuges in parallel.
The operator will choose manually on the HMI of the centrifuge PLC to operate one or two centrifuges depending on the incoming flow rate to the sludge double storage tank ($Q_{in,sludge\ storage}$) as described below:

- $Q_{in,sludge\ storage} \leq Q_{design,centrifuge}$: one centrifuge in operation ; when the flow rate to the sludge double storage tank is in the range of a single centrifuge capacity, the operator will operate with one centrifuge
- $Q_{in,sludge\ storage} > Q_{design,centrifuge}$: two centrifuges in operation ; when the flow rate to the sludge double storage tank is in the range of two centrifuge capacities, the operator will operate with both centrifuges.

In summer operation, the flow rate to the sludge double storage tank is read directly from the flow meter downstream from the sludge splitter box. In winter operation, the operator will be able to estimate the sludge incoming flow rate through the volume change over a certain period in the sludge double storage tank and after having withdrawn the outlet flow rate (capacity of the number of centrifuges in operation.

2.4.2.2 Fault response

When one mixer of the sludge double storage tank fails, an alarm is displayed on the operator HMI and the sludge transfer and dewatering system keeps running in a degraded operation mode.

When the two mixers of the sludge double storage tank fail, an alarm is displayed on the operator HMI and the WTP shutdown sequence is activated.

When a high level is reached in one of the compartments of the sludge double storage tank (high level of LIT5-013 or LIT5-023), an alarm is displayed on the operator HMI.

2.4.2.3 Interlocks

When the level in one compartment of the sludge double storage tank is below the very low level (LSLL switch activated), the associated mixer is stopped and an alarm is displayed on the operator HMI.

When both levels in the two compartments of the sludge double storage tank are below the very low level (LSLL switches activated), the centrifuge feed pumps are stopped and an alarm is displayed on the operator HMI.

When the level in one compartment of the sludge double storage tank is above the very high level (LSHH switch activated), the WTP emergency shutdown sequence is activated.and an alarm is displayed on the operator HMI.

2.5 Clarified water lifting pumps

Functional description by AEM.

2.6 Service water pumps

Functional description by AEM.

2.7 Chemical dosing systems

2.7.1 Caustic soda (NaOH) preparation and dosing system

2.7.1.1 Description

The existing caustic soda preparation and dosing system from Meadowbank is reused. It's composed of :

- A preparation tank with a mixer
- A dosing tank
- Three progressive cavity metering pumps. The capacity of each pump covers 100% of the process needs. One pump is in operation and the remaining pumps are in backup. The operator must change the positions of some manual valves and locally put the pump in auto to use backup

Dry caustic soda and service water are injected by the operator in the preparation tank. The mixer operates for a configurable time if the HMI button is switched to Auto.
When the caustic soda solution is homogenized, the operator transfers the solution to the dosing tank by operating manual isolation valves.

Caustic soda is proportionally dosed to the total raw water flow with a volume compensated integral control loop. A correction is applied to the required NaOH injection flowrate (feedback control loop), based on the pH measurement by AIT1-014 (or AIT1-012, as selected by the operator) in the MPR. AIC1-014 (or AIC1-012) will control the pH value by modulating the speed of caustic soda dosing pumps P9-541 / P9-542 / P9-543.

The dosing point is located upstream from the MPR.

2.7.1.2 Calculation

Equation 1 (mode 1): Calculation of caustic soda flow based on a dosage concentration in mg/L

$$QC_{NAOH} = RC_{NAOH1} * Q_{FEED} / (DENS_{NAOH} * CS_{NAOH} * 10)$$

Where:
QC_{NAOH} = required dosing flowrate of the caustic soda solution (L/h)
RC_{NAOH1} = target dosage concentration of caustic soda in the process (mg/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter
$DENS_{NAOH}$= Density of the dosed caustic soda solution in kg/L
CS_{NAOH}= Caustic soda concentration in the stock solution in %

Equation 2 (mode 2): Calculation of NAOH flow rate based on a dosage concentration in µL/L

$$QC_{NAOH} = (RC_{NAOH2}) * (Q_{FEED})/1000$$

Where:
QC_{NAOH} = required dosing flowrate of the caustic soda (L/h)
RC_{NAOH2} = target dosage concentration of caustic soda in the process (µL/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter

Equation 3: Caustic soda pump speed

The formula below gives the reference speed for metering pumps, in percentage. Calibration of pumps must be done in order to get a linear reference speed curve, on the basis of the pump's capacity

$$(PS_{NAOH}) = 20 + (60 \times ((QC_{NAOH}) - (QC_{20\text{-}NAOH})) / ((QC_{80\text{-}NAOH}) - (QC_{20\text{-}NAOH})))$$

Where:
PS_{NAOH} = Dosing pump speed (%)
QC_{NAOH} = required flowrate of the caustic soda solution as calculated above (L/h)
$QC_{20\text{-}NAOH}$ = Measured caustic soda dosing flowrate at 20% of the pump's calibration curve (L/h) (Entered by the operator on the interface).
$QC_{80\text{-}NAOH}$ = Measured caustic soda dosing flowrate at 80% of the pump's calibration curve (L/h) (Entered by the operator on the interface)

The following parameters shall be available on the operator interface of the caustic soda dosing system:

(RC_{NAOH1}) target dosage concentration of caustic soda in the process (mg/L)
(RC_{NAOH2}) target dosage concentration of caustic soda in the process (µL/L)
($DENS_{NAOH}$) Density of the dosed caustic soda solution in kg/L

($\mathbf{CS}_{NAOH}$) concentration of the caustic soda solution in the stock solution in %
($\mathbf{QC}_{20\text{- }NAOH}$) Caustic soda flow rate at 20% dosing pump speed (L/h)
($\mathbf{QC}_{80\text{- }NAOH}$) Caustic soda flow rate at 80% dosing pump speed (L/h)

The operator will adjust $\mathbf{RC}_{NaOH}$ depending on the alkalinity of the raw water

2.7.1.3 Fault reponse

When the caustic soda preparation mixer faults:

- The mixer is stopped
- An operator alarm is displayed on the operator interface of the main PLC.

Each progressive cavity metering pump is in fault if:

- its high temperature switch is triggered
- its VFD overloads and trips out

When the pump faults:

- An alarm is displayed on the operator interface of the main PLC and the pump is stopped.
- If necessary, the operator can start the back-up metering pump after having operated the proper isolation valves of the dosing skid. The operator will switch the back-up metering pump to automatic mode in replacement of the pump that is in fault.

2.7.1.4 Interlocks

N/A

2.7.2 Coagulant preparation system

The existing coagulant preparation system from Meadowbank is reused. It consists of two tanks of 1000L. The first one prepares the batch and when done, transfers to the second tank for dosing

2.7.2.1 Preparation system sequence

Step #	Step Name	Actions Transition conditions	Preparation Water Valve	Coagulant dry feeder	Preparation mixer	Preparation transfer Pump	H2SO4 dosing
0	Waiting Time	Preparation system ready Waiting for preparation request	C	S	S	S	S

		Low level maturation tank AND No low solid level, dry feeder alarm, mixer alarm, transfer pump alarm or level-meter alarm.					
1	Water filling	Open preparation water valve	O	S	S	S	S
		Level set point for mixer start and H2SO4 dosing reached					
2	Feeding and mixing	Start preparation mixer Start coagulant dry feeder	O	R	R	S	R
		Elapsed feeding time OR full level maturation tank					
3	Water completion	Stop dry feeder Stop H2SO4 dosing	O	S	R	S	S
		Full level maturation tank					
4	Maturation	Close preparation water valve Start of maturation period	C	S	R	S	S
		Elapsed time (Maturation time)					
5	Coagulant transfer waiting time	Stop preparation mixer Solution ready	C	S	S	S	S
		Empty level dosing tank					
6	Coagulant transfer	Start transfer pump	C	S	S	R	S
		Empty level maturation tank					
7	End of transfer	Stop transfer pump	C	S	S	S	S
		- Go to step 0 at end of normal sequence and reset timers - Go to step 8 at end of sequence by a fault					
8	Sequence stopped on a fault	Wait for fault reset	C	S	S	S	S
		- Go to step 1					

Legend

Motor
S : Stop
R : Running

Valve
C : Closed
O : Open

Parameter	Unit
Preparation water volume	L
Delay before starting feeder and mixer	Sec
Maturation tank empty level	mm
Dosing tank empty level	mm
Feeding time	Min
Maturation time	Min

2.7.2.2 Pumps, mixers and motors

Coagulant preparation mixer
Tag: M9-511

Automatic mode

Mixer operates:

- If sequencer is on step 2, 3 or 4
- If E-stop is not activated

Coagulant mixer fault alarm

When the coagulant preparation mixer faults:

- The mixer is stopped
- An operator alarm is displayed on the operator interface of the main PLC
- The preparation sequence is stopped (refer to step 8)

Coagulant transfer pump

Tag: P9-515

Automatic mode
Pump operates:

- If sequencer is on step 6;
- If E-stop is not activated;
- If full level from dosing tank is not activated;
- If empty level from maturation tank is not activated;

Transfer pump fault alarm

The progressive cavity transfer pump is in fault if:

- its high temperature switch is triggered
- its motor faults

When the pump faults:

- An alarm is displayed on the operator interface and the pump is stopped.
- The preparation sequence is stopped (refer to step 8)

Coagulant blower
Tag: B9-513

Automatic mode
The blower operates for a configurable time when the unload bag button is activated

Coagulant blower fault alarm
When the blower faults, an alarm is displayed on the operator interface and the blower is stopped.

Coagulant dry feeder
Tag: DF9-511

Automatic mode
The dry feeder operates:

- If sequencer is on step 2
- If E-stop is not activated.

Dry feeder fault alarm
When the dry feeder faults:

- An alarm is displayed on the operator interface of the main PLC and the feeder is stopped.
- The preparation sequence is stopped (refer to step 8)

2.7.2.3 Valve

Coagulant solenoid preparation water valve
Tag: V9-518

Automatic mode
The valve is open:

- If sequencer is on step 1 to 3
- If E-stop is not activated.

The valve doesn't have status contact. The open fault is activated after a request to open and without change in the water level after a defined time.

Preparation water valve open fault
When the valve fails to open:

- The valve is deactivated
- An alarm is displayed on the operator interface
- The preparation sequence is stopped (refer to step 8)

2.7.2.4 Level transmitters/switches

Maturation tank level transmitter
Tag: LIT9-511

Out of range level transmitter
When the level transmitter is out of range:

- An alarm is displayed on the operator interface
- The preparation sequence is stopped (refer to step 8)

Very low level
When the very low level is reached:

- An alarm is displayed on the operator interface
- The transfer pump is stopped

Low level
When the low level is reached, an alarm is displayed on the operator interface

High level alarm
When the high level is reached, an alarm is displayed on the operator interface

Very high level alarm
When the very high level is reached:

- An alarm is displayed on the operator interface

- The coagulant preparation water valve is closed and the H_2SO_4 dosing is stopped.

Dosing tank level transmitter

Tag: LIT9-512

Out of range level transmitter

When the level transmitter is out of range:
- An alarm is displayed on the operator interface
- The transfer is stopped

Very low level

When the very low level is reached:
- The coagulant dosing pumps are stopped
- An alarm is displayed on the operator interface
- The Actiflo® units stop according to auto stop sequence

Low level

When the low level is reached:
- An alarm is displayed on the operator interface

High level

When the high level is reached:
- An alarm is displayed on the operator interface

Very high level alarm

When the very high level is reached:
- An alarm is displayed on the operator interface
- The transfer pump is stopped

Low solid coagulant level
Tag: LSL9-513

Low level

When the low level is reached:
- An alarm is displayed on the operator interface
- The dry feeder is stopped
- The preparation sequence is stopped (refer to step 8)

2.7.3 Coagulant dosing

2.7.3.1 Description

Coagulant is proportionally dosed to the total raw water flow rate.

For winter dosing, the existing coagulant dosing system from Meadowbank is reused. It's composed of 3 progressive cavity metering pumps (P9-511, P9-512, P9-513). The capacity of each pump covers XX% of the process needs. XX pumps are in operation and the remaining pump is in backup. The operator must change the positions of some manual valves and locally put the pump in auto to use backup.

For summer dosing, a new dosing system is used. It's composed of 2 metering pumps (P9-514, P9-516). The capacity of each pump covers 100% of the process needs. One pump is in operation and the remaining pump is in backup. The operator must change the positions of some manual valves and locally put the pump in auto to use backup.

The dosing point is located in the MPR.

2.7.3.2 Calculation

Equation 1 (mode 1): Calculation of coagulant flow based on a dosage concentration in mg/L

$$QC_{COAG} = RC_{COAG1} * Q_{FEED} / (DENS_{COAG} * CS_{COAG} * 10)$$

Where:
QC_{COAG} = required dosing flowrate of the coagulant solution (L/h)
RC_{COAG1} = target dosage concentration of coagulant in the process (mg/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter
$DENS_{COAG}$= Density of the dosed coagulant solution in kg/L
CS_{COAG}= Coagulant concentration in the stock solution in %

Equation 2 (mode 2): Calculation of COAG flow rate based on a dosage concentration in µL/L

$$QC_{COAG} = (RC_{COAG2}) * (Q_{FEED})/1000$$

Where:
QC_{COAG} = required dosing flowrate of the coagulant (L/h)
RC_{COAG2} = target dosage concentration of coagulant in the process (µL/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter

Equation 3: Coagulant pump speed

The formula below gives the reference speed for metering pumps, in percentage. Calibration of pumps must be done in order to get a linear reference speed curve, on the basis of the pump's capacity

$$(PS_{COAG}) = 20 + (60 \times ((QC_{COAG}) - (QC_{20\text{-}COAG})) / ((QC_{80\text{-}COAG}) - (QC_{20\text{-}COAG})))$$

Where:
PS_{COAG} = Dosing pump speed (%)
QC_{COAG} = required flowrate of the coagulant solution as calculated above (L/h)
$QC_{20\text{-}COAG}$ = Measured coagulant dosing flowrate at 20% of the pump's calibration curve (L/h) (Entered by the operator on the interface).
$QC_{80\text{-}COAG}$ = Measured coagulant dosing flowrate at 80% of the pump's calibration curve (L/h) (Entered by the operator on the interface)

The following parameters shall be available on the operator interface of the coagulant dosing system:

(**RC_{COAG1}**) target dosage concentration of coagulant in the process (mg/L)
(**RC_{COAG2}**) target dosage concentration of coagulant in the process (µL/L)
(**$DENS_{COAG}$**) Density of the dosed coagulant solution in kg/L
(**CS_{COAG}**) concentration of the coagulant solution in the stock solution in %
(**$QC_{20\text{-}COAG}$**) Coagulant flow rate at 20% dosing pump speed (L/h)
(**$QC_{80\text{-}COAG}$**) Coagulant flow rate at 80% dosing pump speed (L/h)

2.7.3.3 Fault response

Dosing pumps are stopped if the coagulant dosing tank level is very low (low low of LIT9-512)

Each metering pump is in fault if:

- its VFD overloads and trips out
- its high temperature switch is triggered (only for progressive cavity pumps)

When a pump faults:

- An alarm is displayed on the operator interface and the pump is stopped.
- If necessary, the operator can start the back-up metering pump after having operated the proper isolation valves of the dosing skid. The operator will switch the back-up metering pump to automatic mode in replacement of the pump that is in fault.

2.7.4 Anionic polymer preparation system

The existing TOMAL automatic polymer preparation system is reused (Tag JB9-521).

The automatic preparation system is independent from the main PLC. It is controlled by a relay panel of which a few signals are transferred to the PLC:

- Polymer preparation system feeder or mixer overload. An alarm is displayed on the operator interface.
- Low level of the polymer storage tank. An alarm is displayed on the operator interface and both Actiflo® units are stopped according to the normal shutdown sequence of the Actiflo.
- Polymer preparation system low service water pressure. An alarm is displayed on the operator interface.
- Polymer preparation system low powder level. An alarm is displayed on the operator interface.

2.7.5 Anionic polymer dosing system

2.7.5.1 Description

Anionic polymer is proportionally dosed to the total raw water flow rate.

For winter dosing, the existing anionic polymer dosing system from Meadowbank is reused. It's composed of 3 progressive cavity metering pumps (P9-521, P9-522, P9-523). Pump P9-521 is designed to operate for MULTIFLO1 and P9-523 for MULTIFLO 2. Pump P9-522 is the backup. Operator must change the positions of some manual valves and locally put the pump in auto to use backup.

The anionic polymer winter dosing system is equipped with water transport valves that help the polymer reach the Mulftiflo units. Solenoid valve V9-521 is related to the winter dosage in Multiflo 1 and solenoid valve V9-522 to the winter dosage in Multiflo 2. V9-521 is open when P9-521 is operating (or P9-522 if it's used in backup instead of P9-521). V9-522 is open when P9-523 is operating (or P9-522 if it's used in backup instead of P9-523).

For summer dosing, a new dosing system is used. It's composed of 3 progressive cavity metering pumps (P9-524, P9-525, P9-526). Pump P9-524 is designed to operate for Actiflo® 1 and P9-526 for Actiflo® 2. Pump P9-525 is the backup. Operator must change the positions of some manual valves and locally put the pump in auto to use backup

The anionic polymer summer dosing system is equipped with water transport valves that help the polymer reach the Actiflo units. Solenoid valve SV15-011 is related to the summer dosage in Actiflo 1 and solenoid valve SV15-021 to the summer dosage in Actiflo 2. SV15-011 is open when P9-524 is operating (or P9-525 if it's used in backup instead of P9-524). SV15-021 is open when P9-526 is operating (or P9-525 if it's used in backup instead of P9-526).

The anionic polymer dosing points are located in the injection tanks of the Actiflo's/Multiflo's.

2.7.5.2 Calculation

Equation 1 (mode 1): Calculation of anionic polymer flow based on a dosage concentration in mg/L

$$QC_{ANPOL} = RC_{ANPOL1} * Q_{FEED} / (DENS_{ANPOL} * CS_{ANPOL} * 10)$$

Where:
QC_{ANPOL} = required dosing flowrate of the anionic polymer solution (L/h)
RC_{ANPOL1} = target dosage concentration of anionic polymer in the process (mg/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter
$DENS_{ANPOL}$= Density of the dosed anionic polymer solution in kg/L
CS_{ANPOL}= Anionic polymer concentration in the stock solution in %

Equation 2 (mode 2): Calculation of ANPOL flow rate based on a dosage concentration in µL/L

$$QC_{ANPOL} = (RC_{ANPOL2}) * (Q_{FEED})/1000$$

Where:
QC_{ANPOL} = required dosing flowrate of the anionic polymer (L/h)
RC_{ANPOL2} = target dosage concentration of anionic polymer in the process (µL/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter

Equation 3: Anionic polymer pump speed

The formula below gives the reference speed for metering pumps, in percentage. Calibration of pumps must be done in order to get a linear reference speed curve, on the basis of the pump's capacity

$$(PS_{ANPOL}) = 20 + (60 \times ((QC_{ANPOL}) - (QC_{20\text{-}ANPOL})) / ((QC_{80\text{-}ANPOL}) - (QC_{20\text{-}ANPOL})))$$

Where:
PS_{ANPOL} = Dosing pump speed (%)
QC_{ANPOL} = required flowrate of the anionic polymer solution as calculated above (L/h)

$QC_{20\text{- ANPOL}}$ = Measured anionic polymer dosing flowrate at 20% of the pump's calibration curve (L/h) (Entered by the operator on the interface).
$QC_{80\text{-ANPOL}}$ = Measured anionic polymer dosing flowrate at 80% of the pump's calibration curve (L/h) (Entered by the operator on the interface)

The following parameters shall be available on the operator interface of the anionic polymer dosing system:
(**RC_{ANPOL1}**) target dosage concentration of anionic polymer in the process (mg/L)
(**RC_{ANPOL2}**) target dosage concentration of anionic polymer in the process (µL/L)
(**$DENS_{ANPOL}$**) Density of the dosed anionic polymer solution in kg/L
(**CS_{ANPOL}**) concentration of the anionic polymer solution in the stock solution in %
(**$QC_{20\text{- ANPOL}}$**) Anionic polymer flow rate at 20% dosing pump speed (L/h)
(**$QC_{80\text{- ANPOL}}$**) Anionic polymer flow rate at 80% dosing pump speed (L/h)

2.7.5.3 Fault response

Dosing pumps are stopped if the anionic polymer dosing tank level is very low (very low level of PT9-522)

Each metering pump is in fault if:

- its VFD overloads and trips out
- its high temperature switch is triggered

When a pump faults:

- An alarm is displayed on the operator interface and the pump is stopped.
- If necessary, the operator can start the back-up metering pump after having operated the proper isolation valves of the dosing skid. The operator will switch the back-up metering pump to automatic mode in replacement of the pump that is in fault.

2.7.6 Sulfuric acid dosing system

2.7.6.1 Description

Sulfuric acid (H2SO4) is proportionally dosed to the quantity of coagulant solution produced.
The sulfuric acid dosing system is composed of two metering pumps. The capacity of each pump covers 100% of the process needs. One pump is in duty and the other is in backup.
The dosing point is located in the maturation tank of the coagulant preparation system.

2.7.6.2 Calculation

Equation 1: Calculation of sulfuric acid flow based on a dosage concentration in µL/L

$$QC_{H2SO4} = Q_{COAG,WATER} * RC_{H2SO4} / 1000$$

Where:
QC_{H2SO4} = required dosing flowrate of the sulfuric acid (L/h)
RC_{H2SO4} = target dosage concentration of sulfuric acid in the coagulant solution (µL/L)
$Q_{COAG,WATER}$= flow rate of service water when filling the coagulant maturation tank (m^3/h) calculated with Equation 2

Equation 2 calculation of the flow rate of service water when filling the coagulant maturation tank

$$Q_{COAG,WATER} = \Delta V_{mat,tank} / \Delta t_{mat,tank}$$

with:

$\Delta V_{mat,tank}$ (m^3), volume variation in the coagulant maturation tank for a water feeding duration of $\Delta t_{mat,tank}$ (h)

and $\Delta V_{mat,tank} = S_{mat,\ tank} * \Delta h_{mat,tank}$

with:

$S_{mat,\ tank}$ (m^2): coagulant maturation tank surface (m^2)

$\Delta h_{mat,tank}$ (m): level variation in the coagulant maturation tank for a water feeding duration of $\Delta t_{mat,tank}$ (h), as measured by level transmitter LIT9-511

Equation 3: Sulfuric acid pump speed

The formula below gives the reference speed for metering pumps, in percentage. Calibration of pumps must be done in order to get a linear reference speed curve, on the basis of the pump's capacity

$$(PS_{H2SO4}) = 20 + (60 \times ((QC_{H2SO4}) - (QC_{20\text{-}H2SO4})) / ((QC_{80\text{-}H2SO4}) - (QC_{20\text{-}H2SO4})))$$

Where:

PS_{H2SO4} = Dosing pump speed (%)

QC_{H2SO4} = required flowrate of the sulfuric acid solution as calculated above (L/h)

$QC_{20\text{-}H2SO4}$ = Measured sulfuric acid dosing flowrate at 20% of the pump's calibration curve (L/h) (Entered by the operator on the interface).

$QC_{80\text{-}H2SO4}$ = Measured sulfuric acid dosing flowrate at 80% of the pump's calibration curve (L/h) (Entered by the operator on the interface)

The following parameters shall be available on the operator interface of the sulfuric acid dosing system:

(RC_{H2SO4}) target dosage concentration of sulfuric acid in the process (µL/L)

($QC_{20\text{-}H2SO4}$) Sulfuric acid flow rate at 20% dosing pump speed (L/h)

($QC_{80\text{-}H2SO4}$) Sulfuric acid flow rate at 80% dosing pump speed (L/h)

2.7.6.3 Fault response

When the operating pump faults, an alarm is displayed on the operator interface.
The operator must change the positions of some manual valves and locally put the pump in auto to use backup.

2.7.6.4 Interlocks

When the chemical storage is equipped with a low level switch or a level transmitter, dosing pumps are automatically disabled from starting when the low level switch or the low level signal of the chemical storage transmitter is triggered.

2.7.7 Cationic polymer make-up system

2.7.7.1 Description

The Hydra-Pol® 3500 preparation system is an automatic machine for batch preparation of Polymer solutions. A screw doses dry Polymer powder into a cone, and then service water wets it in a water whirl. The mixture is discharged into a maturation tank where an agitator agitates the solution during a period of 40 -90 minutes. After this period the solution is transferred into a storage tank.

2.7.7.2 Controls

General

The polymer preparation is controlled by the preparation and transfer sequence outlined in the "Automatic start sequence" below. If equipment involved in the sequence faults during the sequence, an alarm is displayed on the operator interface and the operator must fix the problem and then manually start the sequence again. If this occurs the sequence will restart where it was interrupted unless otherwise indicated.

Calculations

Powder polymer is injected into a preparation/maturation tank using a dosing apparatus. The apparatus operating time is calculated based on its capacity and the desired concentration.

The operating dosing time is calculated with the following formula:

$$Ts = \frac{CONC \times ((LEVstop - LEV) \times Surf)}{Cap} \times 60$$

Ts:	Dosing apparatus operating time (sec.)
CONC:	Polymer concentration adjustable on operator interface (g/l)
LEV:	Preparation/maturation tank measured level (m)
LEVstop:	Preparation/maturation stop level set point (m)
Surf:	Preparation/maturation tank surface (m^2)
Cap:	Dosing apparatus capacity adjustable on operator interface (kg/min)

Note: This formula may also be used to perform a manual preparation in case of automatic system failure. To ensure dosing accuracy, the capacity must be validated by the operator

Automatic Conditions

Conditions for automatic start sequence

The automatic start sequence will be activated when the automatic starting condition is true (Level set point for sequence start-up is reached in the preparation/maturation tank) and the following conditions are met:

1. If remote run request bit is activated;

2. Polymer preparation system components are in Auto start mode.

Automatic start sequence

The automatic preparation system shall follow a given sequence to ensure a consistent Polymer solution. The preparation sequence is described in the following table:

Step #	Step name	Actions Transition conditions	Polymer mixer	Dosing screw	Service water valve	Powder supply valve	Transfer valve
0	Stand-by	Equipment shut off	S	S	C	C	C
		- Level set point for sequence start-up is reached in the preparation/maturation tank -Transfer valve is closed for 30 seconds					
1	Filling	-Remove completed preparation confirmation -Open preparation water valve	S	S	O	C	C
		Level above impeller					
2	Start mixing	Start preparation mixer	R	S	O	C	C
		- Mixer running confirmation - 10 second delay has elapsed					
3	Dosing	-Powder supply valve opened (if DosT not reached) -Start dosing apparatus (if DosT not reached)	R	R	O	O	C
		Dosing time elapsed (DosT) (retentive dosing timer) or High level in preparation/maturation tank					
4	Stop dosing	-Stop powder supply screw -Close powder supply valve	R	S	O	C	C
		Filling stop level					
5	Maturation	Close preparation water valve Start of maturation period	R	S	C	C	C
		Time elapsed 30–180 adjustable minutes (Retentive maturation delay)					
6	End	-Completed preparation confirmation	R	S	C	C	C
		Go to Step 0 at end of normal sequence and reset timers -Go to Step 7 at end of sequence by a fault					
7	**Sequence stopped on a fault**	- Wait for fault reset	S	S	C	C	C
		-Go to Step 1					

Legend

Motor	***Valve***
S: Stop	*C: Closed*
R: Running	*O: Open*

Table 2.7-1: Polymer Preparation Sequence

Note: if there is a power outage before the completed preparation confirmation is active, repeat at Step 1 when the power returns.

Transfer from preparation/maturation tank to storage tank

When the storage tank level reaches the transfer set point, and the completed preparation confirmation is active, the transfer valve opens until the preparation/maturation tank level set point for the start of the next sequence is

reached.

Note: if there is a power outage when the transfer is underway, the operator will manually resume the transfer where it was interrupted when power comes back.

Fault response

The faults associated with the Polymer makeup sequence are:

- Polymer feeder fault
- Low level of solid Polymer
- Low pressure of service water
- Transfer and water valve open/close fault
- Level transmitter fault
- High and Low level in storage tank
- Agitator M9-621 fault

Polymer feeder fault
Tag: FMM9-621/FSM9-621
The feeder and blending tool stop, Polymer preparation system fails and the sequence is stopped until the problem is fixed.

Transfer and water valve open/close fault
Tag: T9-621-V002/SV18-031/SV18-032
Polymer preparation system fails and the sequence is stopped until the problem is fixed.
Note: the valve fail positions are “Normally Closed”.

Low level of solid Polymer
Tag: LSL9-621
Polymer preparation system fails and the sequence is stopped until the problem is fixed.

Low pressure of service water
Tag: PSL18-031
Polymer preparation system fails and the sequence is stopped until the problem is fixed.

LIT Fault
Tag: LT9-621 / LT9-622
Transfer from maturation tank is prohibited, Polymer preparation system fails and the sequence is stopped until the problem is fixed.
An intervention from the operator is necessary to solve the problem and to complete the transfer manually.

Agitator fault
Tag: M9-621
Agitator stops, Polymer preparation system fails and the sequence is stopped until the problem is fixed.

Low level storage tank
Tag: LT9-622
The Polymer dosing pumps are stopped, Polymer preparation system fails and the sequence is stopped until the problem is fixed.

High level storage tank

Tag: LT9-622
Transfer from maturation tank is prohibited, Polymer preparation system fails and the sequence is stopped until the problem is fixed.

If the fault occurs while the system is in the automatic start sequence, the operator needs to solve the problem and reset the fault. The system will then automatically resume at step 1.

If the fault occurs while the system is out of the automatic start sequence, the operator needs to solve the problem and reset the fault. The operator will manually set the system in the required step.

2.7.8 Cationic polymer dosing system

2.7.8.1 Description.

Cationic polymer is proportionally dosed to the inlet flow rate of each centrifuge.
The cationic polymer dosing system is composed of three progressive cavity metering pumps (P9-621, P9-622, P9-623). P9-621 is dedicated to the dosage in centrifuge 1 and P9-623 in centrifuge. P9-622 is used in backup.

Calculations related to the cationic polymer dosing are detailed below:

Equation 1 (mode 1): Calculation of cationic polymer flow rate to centrifuge1 based on a dosage concentration in mg/L

$$QC_{CATPOL1} = RC_{CATPOL1} * Q_{CENTRIF1} / (DENS_{CATPOL} * CS_{CATPOL} * 10)$$

Where:
$QC_{CATPOL1}$ = required dosing flowrate of the cationic polymer solution in centrifuge1 (L/h)
$RC_{CATPOL1}$ = target dosage concentration of cationic polymer in the process (mg/L)
$Q_{CENTRIF1}$ = inlet flow rate to centrifuge1as measured by FIT5-011 (m^3/h)
$DENS_{CATPOL}$= Density of the dosed cationic polymer solution in kg/L
CS_{CATPOL}= Cationic polymer concentration in the stock solution in %

Note: calculation for centrifuge2 is similar. $QC_{CATPOL1}$ is replaced by $QC_{CATPOL2}$, required dosing flowrate of the cationic polymer solution in centrifuge2 (L/h). $Q_{CENTRIF1}$ is replaced by $Q_{CENTRIF2}$ measured by FIT5-021.

Equation 2 (mode 2): Calculation of cationic polymer flow rate to centrifuge1 based on a dosage concentration in µL/L

$$QC_{CATPOL1} = (RC_{CATPOL2}) * (Q_{CENTRIF1})/1000$$

Where:
$QC_{CATPOL1}$ = required dosing flowrate of the cationic polymer solution in centrifuge1 (L/h)
$RC_{CATPOL2}$ = target dosage concentration of cationic polymer in the process (µL/L)
$Q_{CENTRIF1}$ = inlet flow rate to centrifuge1as measured by FIT5-011 (m^3/h)

Note: calculation for centrifuge2 is similar. $QC_{CATPOL1}$ is replaced by $QC_{CATPOL2}$, required dosing flowrate of the cationic polymer solution in centrifuge2 (L/h). $Q_{CENTRIF1}$ is replaced by $Q_{CENTRIF2}$ measured by FIT5-021.

Equation 3: cationic polymer dosing pump speed

$$(PS_{CATPOL}) = 20 + (60 \times ((QC_{CATPOL}) - (QC_{20\text{-}CATPOL})) / ((QC_{80\text{-}CATPOL}) - (QC_{20\text{-}CATPOL})))$$

Where:
PS_{CATPOL} = Dosing pump speed (%)

QC_{CATPOL} = required flowrate of the cationic polymer solution as calculated above (L/h)
$QC_{20-CATPOL}$ = Measured cationic polymer dosing flowrate at 20% of the pump's calibration curve (L/h) (Entered by the operator on the interface).
$QC_{80-CATPOL}$ = Measured cationic polymer dosing flowrate at 80% of the pump's calibration curve (L/h) (Entered by the operator on the interface)

The following parameters shall be available on the operator interface of the cationic polymer dosing system:
(**$RC_{CATPOL1}$**) target dosage concentration of cationic polymer in the process in mg/L
(**$RC_{CATPOL2}$**) target dosage concentration of cationic polymer in the process in µL/L
(**$DENS_{CATPOL}$**) Density of the dosed cationic polymer solution in kg/L
(**CS_{CATPOL}**) Cationic polymer concentration in the stock solution in %
(**$QC_{20-CATPOL}$**) Cationic polymer flow rate at 20% dosing pump speed (L/h)
(**$QC_{80-CATPOL}$**) Cationic polymer flow rate at 80% dosing pump speed (L/h)

2.7.8.2 Fault response

Each progressive cavity metering pump is in fault if:

- Its high temperature switch is triggered
- Its VFD overloads and trips out

When the pump faults:

- An alarm is activated and the pump is stopped.
- The alarm stays active until the problem has been resolved and the alarm has been reset by the operator.
- If necessary, the operator can start the back-up metering pump after having operated the proper isolation valves of the dosing skid. The operator will switch the back-up metering pump to automatic mode in replacement of the pump that is in fault.

2.7.8.3 Interlocks

Cationic polymer dosing pumps are automatically disabled from starting when a very low level is reached in the cationic polymer storage tank.

2.7.9 Potassium permanganate ($KMnO_4$) preparation system

2.7.9.1 Description

The preparation system is an automatic machine for batch preparation of $KMnO_4$ solutions. A screw doses dry $KMnO_4$ powder into a cone, and then service water wets it in a water whirl. The mixture is discharged into a maturation tank where an agitator agitates the solution during a period of 1-30 minutes adjustable, necessary to dilute and homogenize $KMnO_4$ powder in the water. After this period the solution is transferred into a storage tank.

2.7.9.2 Controls

General

The $KMnO_4$ preparation is controlled by the preparation and transfer sequence outlined in the "Automatic start sequence" below. If equipment involved in the sequence faults during the sequence, an alarm is displayed on the operator interface and the operator must fix the problem and then manually start the sequence again. If this occurs the sequence will restart where it was interrupted unless otherwise indicated.

Calculations

Powder $KMnO_4$ is injected into a preparation/maturation tank using a dosing apparatus. The apparatus operating time is calculated based on its capacity and the desired concentration.

The operating dosing time is calculated with the following formula:

$$Ts = \frac{CONC \times ((LEVstop - LEV) \times Surf)}{Cap} \times 60$$

Ts:	Dosing apparatus operating time (sec.)
CONC:	$KMnO_4$ concentration adjustable on operator interface (g/l)
LEV:	Preparation/maturation tank measured level (m)
LEVstop:	Preparation/maturation stop level set point (m)
Surf:	Preparation/maturation tank surface (m^2)
Cap:	Dosing apparatus capacity adjustable on operator interface (kg/min)

Note: This formula may also be used to perform a manual preparation in case of automatic system failure. To ensure dosing accuracy, the capacity must be validated by the operator

Automatic Conditions

Conditions for automatic start sequence

The automatic start sequence will be activated when the automatic starting condition is true (Level set point for sequence start-up is reached in the preparation/maturation tank) and the following conditions are met:

3. If remote run request bit is activated;

4. $KMnO_4$ preparation system components are in Auto start mode.

Automatic start sequence

The automatic preparation system shall follow a given sequence to ensure a consistent $KMnO_4$ solution. The preparation sequence is described in the following table:

Step #	Step name	Actions Transition conditions	$KMnO_4$ mixer	Dosing screw	Service water valve	Powder supply valve
0	Stand-by	Equipment shut off	S	S	C	C
		- Level set point for sequence start-up is reached in the preparation/maturation tank -Transfer valve is closed for 30 seconds				
1	Filling	-Remove completed preparation confirmation -Open preparation water valve	S	S	O	C

		Level above impeller					
2	Start mixing	Start preparation mixer	R	S	O	C	C
		- Mixer running confirmation - 10 second delay has elapsed					
3	Dosing	-Powder supply valve opened (if DosT not reached) -Start dosing apparatus (if DosT not reached)	R	R	O	O	C
		Dosing time elapsed (DosT) (retentive dosing timer) or High level in preparation/maturation tank					
4	Stop dosing	-Stop powder supply screw -Close powder supply valve	R	S	O	C	C
		Filling stop level					
5	Maturation	Close preparation water valve Start of maturation period	R	S	C	C	C
		Time elapsed 1–30 minutes adjustable (Retentive maturation delay)					
6	End	-Completed preparation confirmation	R	S	C	C	C
		Go to Step 0 at end of normal sequence and reset timers -Go to Step 7 at end of sequence by a fault					
7	**Sequence stopped on a fault**	- Wait for fault reset	S	S	C	C	C
		-Go to Step 1					

Legend

Motor	***Valve***
S: Stop	*C: Closed*
R: Running	*O: Open*

Table 2.7-2: $KMnO_4$ Preparation Sequence

Note: if there is a power outage before the completed preparation confirmation is active, repeat at Step 1 when the power returns.

Transfer from preparation/maturation tank to storage tank

When the storage tank level reaches the transfer set point, and the completed preparation confirmation is active, the transfer valve opens until the preparation/maturation tank level set point for the start of the next sequence is reached.

Note: if there is a power outage when the transfer is underway, the operator will manually resume the transfer where it was interrupted when power comes back.

Fault response

The faults associated with the $KMnO_4$ makeup sequence are:

- $KMnO_4$ feeder fault
- Low level of solid $KMnO_4$
- Low pressure of service water
- Transfer and water valve open/close fault
- Level transmitter fault
- High and Low level in storage tank

- Agitator M9-591 fault

$KMnO_4$ feeder fault
Tag: FMM9-591/FSM9-591
The feeder and blending tool stop, $KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.

Transfer and water valve open/close fault
Tag: T9-591-V002/SV15-041/SV15-042
$KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.
Note: the valve fail positions are “Normally Closed”.

Low level of solid $KMnO_4$
Tag: LSL9-591
$KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.

Low pressure of service water
Tag: PSL15-041
$KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.

LIT Fault
Tag: LT9-591 / LT9-592
Transfer from maturation tank is prohibited, $KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.
An intervention from the operator is necessary to solve the problem and to complete the transfer manually.

Agitator fault
Tag: M9-591
Agitator stops, $KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.

Low level storage tank
Tag: LT9-592
The $KMnO_4$ dosing pumps are stopped, $KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.

High level storage tank
Tag: LT9-592
Transfer from maturation tank is prohibited, $KMnO_4$ preparation system fails and the sequence is stopped until the problem is fixed.

If the fault occurs while the system is in the automatic start sequence, the operator needs to solve the problem and reset the fault. The system will then automatically resume at step 1.

If the fault occurs while the system is out of the automatic start sequence, the operator needs to solve the problem and reset the fault. The operator will manually set the system in the required step.

2.7.10 Potassium permanganate ($KMnO_4$) dosing system

2.7.10.1 Description

Potassium permanganate (KMNO4) is proportionally dosed to the total raw water flow rate.
The potassium permanganate dosing system is composed of two metering pumps. The capacity of each pump

covers 100% of the process needs. One pump is in duty and the other is in backup.
The dosing point is located upstream from the MPR.

2.7.10.2 Calculation

Equation 1 (mode 1): Calculation of potassium permanganate flow based on a dosage concentration in mg/L

$$QC_{KMNO4} = RC_{KMNO41} * Q_{FEED} / (DENS_{KMNO4} * CS_{KMNO4} * 10)$$

Where:
QC_{KMNO4} = required dosing flowrate of the potassium permanganate solution (L/h)
RC_{KMNO41} = target dosage concentration of potassium permanganate in the process (mg/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter
$DENS_{KMNO4}$= Density of the dosed potassium permanganate solution in kg/L
CS_{KMNO4}= Potassium permanganate concentration in the stock solution in %

Equation 2 (mode 2): Calculation of KMnO4 flow rate based on a dosage concentration in µL/L

$$QC_{KMNO4} = (RC_{KMNO42}) * (Q_{FEED})/1000$$

Where:
QC_{KMNO4} = required dosing flowrate of the potassium permanganate (L/h)
RC_{KMNO42} = target dosage concentration of potassium permanganate in the process (µL/L)
Q_{FEED}= inlet raw water flow rate (m^3/h) measured by the influent raw water flow meter

Equation 3: Potassium permanganate pump speed

The formula below gives the reference speed for metering pumps, in percentage. Calibration of pumps must be done in order to get a linear reference speed curve, on the basis of the pump's capacity

$$(PS_{KMNO4}) = 20 + (60 \times ((QC_{KMNO4}) - (QC_{20\text{-}KMNO4})) / ((QC_{80\text{-}KMNO4}) - (QC_{20\text{-}KMNO4})))$$

Where:
PS_{KMNO4} = Dosing pump speed (%)
QC_{KMNO4} = required flowrate of the potassium permanganate solution as calculated above (L/h)
$QC_{20\text{-}KMNO4}$ = Measured potassium permanganate dosing flowrate at 20% of the pump's calibration curve (L/h) (Entered by the operator on the interface).
$QC_{80\text{-}KMNO4}$ = Measured potassium permanganate dosing flowrate at 80% of the pump's calibration curve (L/h) (Entered by the operator on the interface)

The following parameters shall be available on the operator interface of the potassium permanganate dosing system:
(RC_{KMNO41}) target dosage concentration of potassium permanganate in the process (mg/L)
(RC_{KMNO42}) target dosage concentration of potassium permanganate in the process (µL/L)
($DENS_{KMNO4}$) Density of the dosed potassium permanganate solution in kg/L
(CS_{KMNO4}) Potassium permanganate concentration in the stock solution in %
($QC_{20\text{-}KMNO4}$) Potassium permanganate flow rate at 20% dosing pump speed (L/h)
($QC_{80\text{-}KMNO4}$) Potassium permanganate flow rate at 80% dosing pump speed (L/h)

2.7.10.3 Fault response

When the operating pump faults, an alarm is displayed on the operator interface.
The operator must change the positions of some manual valves and locally put the pump in auto to use backup.

2.7.10.4 Interlocks

When the chemical storage is equipped with a low level switch or a level transmitter, dosing pumps are automatically disabled from starting when the low level switch or the low level signal of the chemical storage transmitter is triggered.

3 SEQUENCES FOR SUMMER AND WINTER CONFIGURATIONS

3.1 Description

As summer and winter flowrates to be treated differ significantly, two distinct operating configurations are required. Start-up and shut-down sequences for summer and winter configurations are described below.

3.2 Summer configuration

The start-up sequence for the summer configuration is the following:

- Each Multiflo is switched to the Actiflo mode which means :
  - The Multiflo extraction pump is stopped
  - The operator closes the manual isolation valves of the Multiflo sludge extraction pump
  - The operator opens the manual isolation valves of the Actiflo microsand recirculation pumps
  - The start-up sequence of the ACTIFLO is activated (refer to the AEM Amaruq project - ACTIFLO® functional description)
- The sludge splitter box extraction pump is switched to Auto and it will start once the level in the splitter box rises above the very low level switch
- AIC4-011 turbidity control loop is activated
- Coagulant winter dosing pumps (P9-511, P9-512 and P9-513) are stopped and coagulant summer dosing pumps (P9-514 and P9-516) are started
- Anionic polymer winter dosing pumps (P9-521, P9-522 and P9-523) are stopped and anionic polymer summer dosing pumps (P9-524, P9-525 and P9-526) are started

3.3 Winter configuration

The start-up sequence for the winter configuration is the following:

- Each Actiflo is switched to the Multiflo mode which means :
  - The Actiflo microsand recirculation pumps are stopped
  - The operator closes the manual isolation valves of the Actiflo microsand recirculation pumps
  - The operator opens the manual isolation valves of the Multiflo sludge extraction pump
  - The start-up sequence of the MULTIFO is activated (refer to the MULTIFLO functional description)
- AIC4-011 turbidity control loop will be de-activated
- Until the sludge splitter box is drained by the operator, its extraction pump is kept running. This maintains

a sludge recirculation loop in the splitter box in order to prevent the settling of the sludge and the risk of plugging.

- Coagulant summer dosing pumps (P9-514 and P9-516) are stopped and coagulant winter dosing pumps (P9-511, P9-512 and P9-513) are started
- Anionic polymer summer dosing pumps (P9-524, P9-525 and P9-526) are stopped and anionic polymer winter dosing pumps (P9-521, P9-522 and P9-523) are started

4 APPENDIX A – ALARMS, PARAMETERS AND SET POINTS (TO BE COMPLETED)

LEFT BLANK

AGNICO EAGLE MINES Ltd - AMARUQ

Actiflo® – ACP

PROCESS CONTROL DESCRIPTION

VEOLIA WATER TECHNOLOGIES CANADA
www.veoliawatertechnologies.com

REVISION STATUS

Issue	Date	Created	Reviewed	Approved	Description of Changes
1	2018/07/18	FV	GP	CB	First Issue
2	2018/08/09	FV	GP	CB	Changes in interlocks section and emergency shutdown

TABLE OF CONTENTS

INTRODUCTION

1.1 REFERENCE DOCUMENTS

Document Number	Name
5000218009_PI_0001_GEN_VWT	PI001 _Process and Instrumentation diagram
5000218009_FD_0001_GEN_rev1	Project overall functional description

1.2 PROCESS OVERVIEW

Actiflo units are based on the ballasted flocculation process. The key feature of this process is that very fine sand (85 µm or 130 µm size), termed “microsand” is added to the raw water following coagulant addition. A polymer is also added that binds the microsand to the floc, creating a ballasted floc with greatly increased effective density. The ballasted flocculation process is capable of being shut down when treatment capacity is not needed and then rapidly restarted when needed.

Ballasted flocculation works with most types of waters but is most advantageous with raw waters that either experience high turbidity raw water conditions (up to 2 500 NTU) and/or rapidly changing raw water turbidity conditions. It is also suitable for low turbidity, highly colored raw waters.

It consists of a coagulation basin, an injection basin, a maturation basin, and a lamella tube clarifier. Coagulant is added at the inlet and subsequent formation of microfloc takes place in the coagulant basin prior to addition of microsand and polymer in the injection basin. The water then flows into the maturation tank where bridging between the microsand and the destabilized suspended solids occurs.

The ballasted flocs settle in the clarifier portion of the system where they are collected by a rake mechanism. Typically 3% to 6% of the unit’s design raw water flow is continuously withdrawn from the clarifier and pumped to a hydrocyclone system which separates the microsand from the sludge. The recovered microsand (typically 20% of the recycled flow) is reused in the process. A small quantity of the microsand is not recovered by the hydrocyclones and is discharged with the sludge. Thus the lost microsand needs to be made up by periodically adding it to the process (typically 1 to 3 mg/L). After sand separation, sludge are partially wasted and recycled with the sludge withdrawn from the clarifier. Approximately 1% to 2,4% of flow becomes waste or residuals stream.

1.3 List of Abbreviations

The following abbreviations are used in the text of this document.

- HMI: Human/Machine Interface
- H-O-A: Hand-Off-Auto
- PLC: Programmable Logic Controller
- LCP: Local Control Panel
- VFD: Variable Frequency Drive
- VWT: Veolia Water Technologies Canada

1.4 List of Units

The following lists the parameters referred to in this document and the units they are measured in unless otherwise specified.

- Concentration (in general): mg/L
- Dosing rate: mL/L
- Flow rate (main process): m^3/h
- Flow rate (chemical dosing): LPH
- Level in the tanks: %
- pH: -
- Pressure: PSIg
- Temperature: °C
- Turbidity: mg/L or NTU

ACTIFLO® CONTROL DESCRIPTION

1.5 EQUIPMENT AND INSTRUMENT

Refer to the overall functional description of the project for tags and descriptions of the controlled equipment of each ACTIFLO.

1.6 OPERATING MODES OVERVIEW

There are two primary modes for each ACTIFLO®: Manual and Semi-Automatic. The Manual mode is designed for operation of individual equipment. The Semi-Auto mode is designed for operation of the ACTIFLO® system as a whole.

Local mode

In local Mode, the operator can operate individual equipment.

Equipment can be started manually at the LCP using the Hand position of the H-O-A.

HMI manual mode

The operator can operate individual equipment through HMI control if the Local switch on that equipment is in the Auto position. Manual operation from the HMI provides the same equipment protection and alarming as Semi-Auto.

Semi-Auto

Semi-Auto mode allows the operator to initiate the ACTIFLO® system start-up and shutdown sequences from HMI or remotely.

NOTE: Train equipment cannot be controlled manually while in Semi-Auto operation.

The coagulation mixer or injection mixer, maturation mixer, scraper, and at least one sand pump H-O-As must be in Auto to enable Semi-Automatic control of all respective equipment at the HMI and at the LCP. All startup sequences are described below. Each ACTIFLO® train and its associated equipment are controlled as an independent system by the PLC.

The table below presents the control modes summary.

Table 1: Summary of Control Modes

	Manual		Semi-Auto
	Local	**HMI Manual**	
Control Functions	N/A	N/A	Allowed (PLC)
Initiation of Semi-Automatic functions	N/A	N/A	Operator or Remote Start-up Initiation Required
HMI Operation of Individual Equipment	N/A	Allowed (virtual HOA on HMI)	Not Allowed
Local Operation of Individual Equipment	Allowed By HOA on LCP	N/A	Not Allowed

1.7 PERMISSIVE

Permissive to allow initiation of the Semi-Automatic start sequence are:

- H-O-A selector switches for mixers, scraper and at least one sand pump, are in Auto at the HMI and at the LCP.
- Mixers (whichever is in Auto at HMI and LCP), scraper, and the above mentioned sand pump do not have existing equipment alarms.
- Aforementioned equipment alarms must be manually reset.

1.8 OPTIONS

Idle option

When the idle option is enabled, the Actiflo keeps the inlet valve open all the time.

Mixing option

When the mixing option is enabled, a unit in Semi-Auto mode left idle will start some mixer to move the sand into the tank to avoid the sedimentation.

1.9 SEMI-AUTO TRAIN RESPONSE TO EQUIPMENT CONDITIONS

1.9.1 Equipment Removed From Auto PLC Response

If the mixers and the scraper are removed from Auto at the LCP while the PLC is running in Semi-Automatic control of the ACTIFLO® system, the PLC will initiate a Shutdown Sequence as described in section 1.11.2.

Since the scraper will not be operational, the Shutdown Sequence will consist of the sand recirculation pumps running for the durations indicated in section 1.11.2.

If the lead sand pump is removed from Auto at the LCP, the PLC will sequentially initiate operation of the next available pump. If all sand pumps are removed from Auto or no additional pumps are available, the PLC will initiate an emergency shutdown of all equipment.

NOTE: No alarm will be generated if an ACTIFLO® system shutdown is initiated due to a piece of equipment being removed from Auto by the operator.

1.9.2 Equipment Failure PLC Response

If the coagulation mixer fails during Semi-Automatic control of the ACTIFLO® system, the system will continue to run.

Should the injection mixer or the maturation mixer fail at any time during Semi-Automatic control of the ACTIFLO® system, the PLC will issue an equipment alarm and will initiate a Shutdown Sequence as described in section 1.11.2.

Should the scraper fail at any time during operation or start-up, the PLC will issue an equipment alarm and will initiate a Shutdown Sequence as described in section 1.11.2. Since the scraper will not be operational, the Shutdown Sequence will consist of the sand recirculation pumps running for the durations indicated in section 1.11.2.

Should lead sand pump fail, the PLC will issue an equipment alarm and sequentially initiate operation of the next available pump. If all sand pumps fail or no additional pumps are available, the PLC will initiate an emergency shutdown of all equipment.

NOTE: An AVAILABLE sand pump is defined as one that is placed in Auto at the LCP and does not have any existing un-reset alarm conditions.

1.10 RECIRCULATION PUMPS LOGIC

1.10.1 Duty/Assist Orientation

When two recirculation lines are provided they can be set with priority. The two sand pumps operate in a Duty / Assist orientation. If all sand pumps are in "auto" but not running, the pump set as priority (duty) will start when the start condition will be met. If the influent quality deteriorates, as indicated by an increase in raw water turbidity, the operator can use the second recirculation line by starting the second pump from the HMI.

The sand pumps priority (duty or assist) is changed manually by the operator anytime or is changed automatically when the plant stops.

1.11 SEQUENCES OF FUNCTIONS

1.11.1 Start-up Sequence

If all permissive conditions are present and no respective equipment alarms exist, the HMI will display **"Train Ready"**. The Start-up Sequence can now be initiated via the HMI or remotely.

NOTE: To prevent damage to the equipment, the Train must have water in the tanks above the mixer impeller elevations prior to Start-up (to be checked by the operator).

To start the train when "Train Ready" is displayed on the HMI, the operator presses the "Train Start" pushbutton. A starting system displays "Train Starting" at the HMI. The start-up sequence automatically cycles through the steps listed below.

1. System Start-up Initiated:
    a. **Start the Duty Sand Pump**

If a failure occurs, the duty pump will be locked out in the PLC and the next available pump will be assigned as the lead pump. The PLC will then attempt to continue operation. This cycle will occur until a sand pump starts or all sand pumps have been locked out. If all sand pumps are locked out, the PLC will immediately abort the start-up.

2. Delay 30 seconds (adjustable):
    a. **Start the Scraper**

If a Scraper failure occurs initiate a Shutdown Sequence.

3. Delay 10 seconds (adjustable):
    a. **Start the mixers**. These mixers start are respectively staggered by 5 seconds.

If a maturation Mixer failure occurs initiate a Shutdown Sequence.

4. Delay 10 seconds (adjustable):
    a. Start the Chemical Feed Pumps
    b. Open Raw water Valve. Open Water Polymer Carrier Solenoid valve
    c. HMI will display **"Train Started"**

If any Duty Chemical Feed Pump is not available while in operation, the Stand-by pump shall be initiated. The duty pump will not be locked out so when the pump is placed back into Semi-Auto, it will resume operation. Duty chemical feed pump alternation is manual and available only at the HMI.

The Operator can terminate the start-up at any point in the sequence by pressing the "Train Stop" pushbutton. If any pertinent equipment fails during the start-up sequence, the PLC will initiate a train shutdown. The operator can correct the failure, and then resume the start-up sequence from the current shutdown sequence step by pressing the "Train Start" pushbutton.

1.11.2 Shutdown Sequence

Normal shutdown sequence
When in Semi-Automatic mode, the operator may implement the Shutdown Sequence at any time from the HMI or remotely. During shutdown, the HMI will display "Train Stopping".

The shutdown sequence automatically cycles through the steps listed below.

1. System Shutdown Initiated:
    a. Close the Influent Valve, Shutdown the Chemical Feed Pumps, Shutdown the mixers. Stop Water Polymer Carrier Solenoid valve.

2. Delay an (Operator Adjustable) (10-30 minutes):
    a. Shutdown the Scraper
    b. Start the Standby Sand Pump

3. Delay 5 minutes:
    a. Shutdown the Duty Sand Pump and Shutdown the standby Sand Pump

NOTE: This delay allows purging of sand and sludge contained in the settling tank and piping and re-deposits it back into the Maturation tank.

The operator can initiate the Train start-up sequence from the current shutdown sequence step by pressing the "Train Start" pushbutton without stopping the equipment already started.

Emergency shutdown sequence

The emergency shutdown sequence automatically cycles through the steps listed below.

1. System shutdown initiated:
   - **a.** Close the influent valve, shutdown the chemical feed pumps, shutdown the mixers, shutdown the scraper, shutdown the microsand recirculation pumps, close the water polymer carrier solenoid valves.

1.12 ALARM/FAILURE CONDITIONS AND PLC RESPONSES

1.12.1 Alarm Priorities

Alarms are grouped in to 3 priority levels for various attention requirements:

Emergency alarms:

1. Needs immediate operator attention.
2. The ACTIFLO® unit will initiate the emergency shutdown sequence.

Fatal alarms:

1. Needs immediate operator attention.
2. The ACTIFLO® unit will initiate the stop sequence.

Warning alarms:

1. Does not need immediate operator attention.

If the ACTIFLO® unit was stopped by an Emergency alarm or Fatal alarm, it will not restart automatically. The operator must remove alarm condition and reset the alarm. Then press the start button on the operator interface will restart the unit if all automatic start sequence conditions are satisfied. In case of remote control, the system will wait for rising edge of the remote start signal.

1.13 SAFETY

1.13.1 Emergency Stop

Emergency stop actions

When an emergency stop button is activated on an equipment, an alarm is triggered. The fault associated with this alarm will latch.

During emergency stop, many stopping actions are initiated on the equipment. These actions are presented in sections describing the relevant equipment.

Recovery after emergency stop

When all emergency stop buttons are back into normal position, the fault associated with an alarm is maintained until the operator presses the reset button.

1.13.2 Control Power Failure PLC Response

Should control power fail at any time during Semi-Automatic control of the ACTIFLO® system, the PLC will issue an alarm and will initiate a Shutdown Sequence as described in this document. Systems with an Uninterruptable Power Supply (UPS) will see the alarm as the condition occurs. Systems without an UPS will see the alarm upon restoration of power. There is a ten (10) second delay upon restoring power, and then the train will enter the Shutdown Sequence as described in this document. If the restored power does not include the actual motor controls, a run status will not be received by the PLC and equipment (pumps and scraper) will shut down immediately without a re-inventory of the sand to the maturation tank. If the unit is configured to resume via the HMI, it will automatically resume to the last known state. Otherwise the unit will remain in Stop.

1.14 CALCULATED PARAMETERS

The following sections explain the main calculations made in the control of the ACTIFLO® system.

The PLC calculates the chemical feed rates and controls the chemical metering pumps using the following procedure. The chemical feed rate is based on:

1. The influent raw water flow rate
2. The chemical dose
3. The physical properties of the chemicals
4. The capacity and settings of the metering pump

The influent raw water flow rate is obtained through the raw water flow meter, which sends a signal to the PLC.

The influent raw water turbidity rate is obtained through the raw water turbidimeter and the raw water pH is obtained through the raw water pH meter.

The chemical dose, physical properties and metering pump capacity are input by the user/operator at the HMI.

The basic equation for the chemical feed rate is:

$$\text{Chemical feed rate} = \frac{\text{influent flow rate} \times \text{chemical dose}}{\text{stock chemical concentration}}$$

This equation is the general form for all chemical feed rates that use flow pacing control, including coagulant and polymer.

1.14.1 Flow Pace Control

The way the PLC uses these calculations to determine the chemical metering pump output is:

1. The chemical feed rate equations are programmed into the PLC.
2. The user/operator inputs the chemical dose, physical properties, and maximum chemical metering pump capacity at the HMI on the ACTIFLO® control panel. The PLC calculates the specific chemical feed rate based on the user/operator inputs and the influent (raw water) flow to the train.
3. The calculated feed rate is then converted by the PLC into a percent speed, based on the maximum capacity of the metering pumps. This signal is then sent to the metering pump.

1.15 INTERLOCKS

1.15.1 Actiflo® High Level Switch

A float over the settling tank is used as a High Level switch. When the switch is activated, stop the corresponding Actiflo® unit according to the automatic stop sequence.

1.15.2 Scraper Torque

The torque detector/alarm is independent from the PLC. So it is enabled (will stop the scraper) through a hardwired interlock to the scraper starter in the corresponding Actiflo® control panel.

1.15.2.1 High High Scraper Torque

A high torque alarm is activated when the torque is higher than the adjustable set point for more than the adjustable delay. Those adjustable variables are set on the microcontroller installed in the panel.

When the alarm is activated, the scraper is stopped and then the Actiflo® is stopped according to the automatic stop sequence.

1.15.3 Maturation Mixer

The maturation mixer cannot run if the scraper is not running.

1.15.4 Scraper

The Scraper is interlocked with the microsand pumps; at least one microsand pump has to be running for the scraper to run.

SYSTEM AND COMMUNICATION

The ACTIFLO® control panel PLC is capable of providing the following global statuses over the main plant PLC network: Global “Ready,” and Global “Fail.”

A Global “Ready” status indicates the system is ready to accept a Global “Start/Stop” command from the main plant PLC.

When the ACTIFLO® system receives a Global “Start” command, the Start-Up Sequence is initiated as described in section 1.11.1 above; this holds true for both Start-Up under normal conditions as well as for Start Up after a power failure.

When the ACTIFLO® system receives a Global “Stop” command under normal conditions, the Shutdown Sequence is initiated as described in section 1.11.2 above.

1.16 HARDWIRE SIGNALS

The following electrical signals are used to communicate some information about the Actiflo trains:

Name	Type	Description	True
Start/Stop	DI	To Start/Stop the unit Remotely	Start the unit
Water Demand	DI	To require the production of water by the Actiflo	Start a production Sequence
Status - In Service	DO	Actiflo In Service Step	
Status - Alarm Active	DO	Warning or Fatal Alarm Active	

AGNICO EAGLE MINES Ltd - AMARUQ

Multiflo

PROCESS CONTROL DESCRIPTION

VEOLIA WATER TECHNOLOGIES CANADA
www.veoliawatertechnologies.com

REVISION STATUS

Issue	Date	Created	Reviewed	Approved	Description of Changes
1	2018/07/18	FV	GP	CB	First Issue
2	2018/08/09	FV	GP	CB	Changes in interlocks section and emergency shutdown

TABLE OF CONTENTS

INTRODUCTION

1.1 REFERENCE DOCUMENTS

Document Number	Name
5000218009_PI_0001_GEN_VWT	PI001 _Process and Instrumentation diagram
5000218009_FD_0001_GEN	Project overall functional description

1.2 PROCESS OVERVIEW

To be completed

1.3 LIST OF ABBREVIATIONS

The following abbreviations are used in the text of this document.

- HMI: Human/Machine Interface
- H-O-A: Hand-Off-Auto
- PLC: Programmable Logic Controller
- LCP: Local Control Panel
- VFD: Variable Frequency Drive
- VWT: Veolia Water Technologies Canada

1.4 LIST OF UNITS

The following lists the parameters referred to in this document and the units they are measured in unless otherwise specified.

- Concentration (in general): mg/L
- Dosing rate: mL/L
- Flow rate (main process): m^3/h
- Flow rate (chemical dosing): LPH
- Level in the tanks: %
- pH: -
- Pressure: PSIg
- Temperature: °C

- Turbidity: mg/L or NTU

MULTIFLO CONTROL DESCRIPTION

1.5 EQUIPMENT AND INSTRUMENT

Refer to the overall functional description of the project for tags and descriptions of the controlled equipment of each MULTIFLO.

1.6 OPERATING MODES OVERVIEW

There are two primary modes for each MULTIFLO: Manual and Semi-Automatic. The Manual mode is designed for operation of individual equipment. The Semi-Auto mode is designed for operation of the MULTIFLO system as a whole.

Local mode

In local Mode, the operator can operate individual equipment.

Equipment can be started manually at the LCP using the Hand position of the H-O-A.

HMI manual mode

The operator can operate individual equipment through HMI control if the Local switch on that equipment is in the Auto position. Manual operation from the HMI provides the same equipment protection and alarming as Semi-Auto.

Semi-Auto

Semi-Auto mode allows the operator to initiate the MULTIFLO system start-up and shutdown sequences from HMI or remotely.

NOTE: Train equipment cannot be controlled manually while in Semi-Auto operation.

The coagulation mixer or injection mixer, maturation mixer, scraper and the extraction pump H-O-As must be in Auto to enable Semi-Automatic control of all respective equipment at the HMI and at the LCP. All startup sequences are described below. Each MULTIFLO train and its associated equipment are controlled as an independent system by the PLC.

The table below presents the control modes summary.

Table 1: Summary of Control Modes

	Manual		Semi-Auto
	Local	**HMI Manual**	
Control Functions	N/A	N/A	Allowed (PLC)
Initiation of Semi-Automatic functions	N/A	N/A	Operator or Remote Start-up Initiation Required
HMI Operation of Individual Equipment	N/A	Allowed (virtual HOA on HMI)	Not Allowed
Local Operation of Individual Equipment	Allowed By HOA on LCP	N/A	Not Allowed

1.7 PERMISSIVE

Permissive to allow initiation of the Semi-Automatic start sequence are:

- H-O-A selector switches for mixers, scraper and the extraction pump, are in Auto at the HMI and at the LCP.
- Mixers (whichever is in Auto at HMI and LCP), scraper, and the extraction pump do not have existing equipment alarms.
- Aforementioned equipment alarms must be manually reset.

1.8 SEMI-AUTO TRAIN RESPONSE TO EQUIPMENT CONDITIONS

1.8.1 Equipment Removed From Auto PLC Response

If the mixers and the scraper are removed from Auto at the LCP while the PLC is running in Semi-Automatic control of the MULTIFLO system, the PLC will initiate a Shutdown Sequence as described in section 1.10.2.

If the Multiflo extraction pump is removed from Auto, the PLC will initiate an emergency shutdown of all equipment.

NOTE: No alarm will be generated if a MULTIFLO system shutdown is initiated due to a piece of equipment being removed from Auto by the operator.

1.8.2 Equipment Failure PLC Response

If the coagulation mixer fails during Semi-Automatic control of the MULTIFLO system, the system will continue to run.

Should the injection mixer or the maturation mixer fail at any time during Semi-Automatic control of the MULTIFLO system, the PLC will issue an equipment alarm and will initiate a Shutdown Sequence as described in section 1.10.2.

Should the scraper fail at any time during operation or start-up, the PLC will issue an equipment alarm and will initiate a Shutdown Sequence as described in section 1.10.2.

Should the Multiflo extraction pump fail, the PLC will initiate an emergency shutdown of all equipment.

1.9 EXTRACTION PUMP LOGIC

The Multiflo extraction pump will operate in batches. The operator will be able to adjust the running time and the lag time between the batches on the HMI.

1.10 SEQUENCES OF FUNCTIONS

1.10.1 Start-up Sequence

If all permissive conditions are present and no respective equipment alarms exist, the HMI will display **"Train Ready"**. The Start-up Sequence can now be initiated via the HMI or remotely.

NOTE: To prevent damage to the equipment, the Train must have water in the tanks above the mixer impeller elevations prior to Start-up (to be checked by the operator).

To start the train when "Train Ready" is displayed on the HMI, the operator presses the "Train Start" pushbutton. A starting system displays "Train Starting" at the HMI. The start-up sequence automatically cycles through the steps listed below.

1. System Start-up Initiated:
    a. **Start the extraction pump**

If the pump fails to start, the PLC will immediately abort the start-up.

2. Delay 30 seconds (adjustable):
    a. **Start the Scraper**

If a Scraper failure occurs initiate a Shutdown Sequence.

3. Delay 10 seconds (adjustable):
    a. **Start the mixers**. These mixers start are respectively staggered by 5 seconds.

If a maturation Mixer failure occurs initiate a Shutdown Sequence.

4. Delay 10 seconds (adjustable):
    a. Start the Chemical Feed Pumps
    b. Open Raw water Valve.
    c. HMI will display **"Train Started"**

If any Duty Chemical Feed Pump is not available while in operation, the Stand-by pump shall be initiated. The duty pump will not be locked out so when the pump is placed back into Semi-Auto, it will resume operation. Duty chemical feed pump alternation is manual and available only at the HMI.

The Operator can terminate the start-up at any point in the sequence by pressing the "Train Stop" pushbutton. If any pertinent equipment fails during the start-up sequence, the PLC will

initiate a train shutdown. The operator can correct the failure, and then resume the start-up sequence from the current shutdown sequence step by pressing the “Train Start” pushbutton.

1.10.2 Shutdown Sequence

Normal shutdown sequence
When in Semi-Automatic mode, the operator may implement the Shutdown Sequence at any time from the HMI or remotely. During shutdown, the HMI will display “Train Stopping”.

The shutdown sequence automatically cycles through the steps listed below.

1. System Shutdown Initiated:
   - **a.** Close the Influent Valve, Shutdown the Chemical Feed Pumps, Shutdown the mixers.

2. Delay an (Operator Adjustable) (10-30 minutes):
   - **a.** Shutdown the Scraper
   - **b.** Shutdown the extraction pump

The operator can initiate the Train start-up sequence from the current shutdown sequence step by pressing the “Train Start” pushbutton without stopping the equipment already started.

Emergency shutdown sequence
The emergency shutdown sequence automatically cycles through the steps listed below.

1. System Shutdown Initiated:
   - **a.** Close the influent valve, shutdown the chemical feed pumps, shutdown the mixers, shutdown the scraper, shutdown the microsand recirculation pumps, close the water polymer carrier solenoid valves.

1.11 Alarm/Failure Conditions and PLC Responses

1.11.1 Alarm Priorities

Alarms are grouped in to 3 priority levels for various attention requirements:

Emergency alarms:

1. Needs immediate operator attention.
2. The MULTIFLO unit will initiate the emergency shutdown sequence.

Fatal alarms:

1. Needs immediate operator attention.
2. The MULTIFLO unit will initiate the stop sequence.

Warning alarms:

1. Does not need immediate operator attention.

If the MULTIFLO unit was stopped by an Emergency alarm or Fatal alarm, it will not restart automatically. The operator must remove alarm condition and reset the alarm. Then press the start button on the operator interface will restart the unit if all automatic start sequence conditions are satisfied. In case of remote control, the system will wait for rising edge of the remote start signal.

1.12 SAFETY

1.12.1 Emergency Stop

Emergency stop actions

When an emergency stop button is activated on an equipment, an alarm is triggered. The fault associated with this alarm will latch.

During emergency stop, many stopping actions are initiated on the equipment. These actions are presented in sections describing the relevant equipment.

Recovery after emergency stop

When all emergency stop buttons are back into normal position, the fault associated with an alarm is maintained until the operator presses the reset button.

1.12.2 Control Power Failure PLC Response

Should control power fail at any time during Semi-Automatic control of the MULTIFLO system, the PLC will issue an alarm and will initiate a Shutdown Sequence as described in this document. Systems with an Uninterruptable Power Supply (UPS) will see the alarm as the condition occurs. Systems without an UPS will see the alarm upon restoration of power. There

is a ten (10) second delay upon restoring power, and then the train will enter the Shutdown Sequence as described in this document. If the restored power does not include the actual motor controls, a run status will not be received by the PLC and equipment (pumps and scraper) will shut down immediately. If the unit is configured to resume via the HMI, it will automatically resume to the last known state. Otherwise the unit will remain in Stop.

1.13 CALCULATED PARAMETERS

The following sections explain the main calculations made in the control of the MULTIFLO system.

The PLC calculates the chemical feed rates and controls the chemical metering pumps using the following procedure. The chemical feed rate is based on:

1. The influent raw water flow rate
2. The chemical dose
3. The physical properties of the chemicals
4. The capacity and settings of the metering pump

The influent raw water flow rate is obtained through the raw water flow meter, which sends a signal to the PLC.

The influent raw water turbidity rate is obtained through the raw water turbidimeter and the raw water pH is obtained through the raw water pH meter.

The chemical dose, physical properties and metering pump capacity are input by the user/operator at the HMI.

The basic equation for the chemical feed rate is:

$$\text{Chemical feed rate} = \frac{\text{influent flow rate} \times \text{chemical dose}}{\text{stock chemical concentration}}$$

This equation is the general form for all chemical feed rates that use flow pacing control, including coagulant and polymer.

1.13.1 Flow Pace Control

The way the PLC uses these calculations to determine the chemical metering pump output is:

1. The chemical feed rate equations are programmed into the PLC.

2. The user/operator inputs the chemical dose, physical properties, and maximum chemical metering pump capacity at the HMI on the MULTIFLO control panel. The PLC calculates the specific chemical feed rate based on the user/operator inputs and the influent (raw water) flow to the train.
3. The calculated feed rate is then converted by the PLC into a percent speed, based on the maximum capacity of the metering pumps. This signal is then sent to the metering pump.

1.14 INTERLOCKS

1.14.1 Multiflo High Level Switch

A float over the settling tank is used as a High Level switch. When the switch is activated, stop the corresponding Multiflo unit according to the automatic stop sequence.

1.14.2 Scraper Torque

The torque detector/alarm is independent from the PLC. So it is enabled (will stop the scraper) through a hardwired interlock to the scraper starter in the corresponding Multiflo control panel.

1.14.2.1 High High Scraper Torque

A high torque alarm is activated when the torque is higher than the adjustable set point for more than the adjustable delay. Those adjustable variables are set on the microcontroller installed in the panel.

When the alarm is activated, the scraper is stopped and then the Multiflo is stopped according to the automatic stop sequence.

1.14.3 Maturation Mixer

The maturation mixer cannot run if the scraper is not running.

1.14.4 Scraper

The scraper is interlocked with the multiflo extraction pump; the pump has to be running for the scraper to run.

SYSTEM AND COMMUNICATION

The MULTIFLO control panel PLC is capable of providing the following global statuses over the main plant PLC network: Global “Ready,” and Global “Fail.”

A Global “Ready” status indicates the system is ready to accept a Global “Start/Stop” command from the main plant PLC.

When the MULTIFLO system receives a Global “Start” command, the Start-Up Sequence is initiated as described in section 1.10.1 above; this holds true for both Start-Up under normal conditions as well as for Start Up after a power failure.

When the MULTIFLO system receives a Global “Stop” command under normal conditions, the Shutdown Sequence is initiated as described in section 1.10.2 above.

1.15 HARDWIRE SIGNALS

The following electrical signals are used to communicate some information about the Multiflo trains:

Name	Type	Description	True
Start/Stop	DI	To Start/Stop the unit Remotely	Start the unit
Water Demand	DI	To require the production of water by the Multiflo	Start a production Sequence
Status - In Service	DO	Multiflo In Service Step	
Status - Alarm Active	DO	Warning or Fatal Alarm Active	

5 – ELECTRICITY AND CONTROL

5.2 – WIRING DIAGRAMS

LEFT BLANK